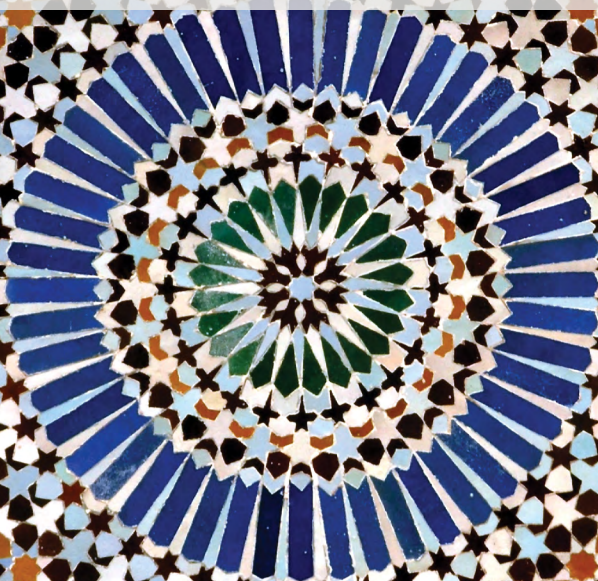




Science at the Universities of the Muslim World

Foreword by:
Tan Sri Zakri Abdul Hamid
Science Advisor to the Prime Minister of Malaysia



Edited by:
Nidhal Guessoum and Athar Osama

With Contributions from:

Moneef R. Zou'bi
Adil Najam
Nadia M. Alhasani
Mustafa El-Tayeb

Ameenah Gurib-Fakim
Jamal Mimouni
Lee Yee Cheong
Abdur Razak Dzulkifli

Bruce Alberts
Michael Reiss
S. Shoaib H. Zaidi
Yusoff Suleiman

Report of Zakri Task Force
on
Science at the Universities of the Muslim World

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Yosoff Sulaiman

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Task Force on Science at the Universities of the Muslim World

The Task Force on Science at the Universities of the Muslim World is the first in a series of Task Forces aimed at catalysing a dialogue, debate, and discourse on big questions and subsequent policy actions on issues of critical importance at the intersection of science, society, and Islam. In doing so, it also seeks to reclaim the narrative of science within the Islamic Community - a narrative that, in the recent years, has been imposed from outside rather than created from inside - and hence begin an inside-out process of scientific revival within the Islamic World.

The 'Big Question' that the Task Force sought to address is:

Are universities the main culprits in the sorry state of science in the Muslim world? What (positive) role should they be playing?

Working with the leadership of the Task Force, the Muslim World Science Initiative notified the following Members of the Task Force in July 2014:

Task Force Leadership:

Chair: Tan Sri Prof. Zakri Abdul Hamid, Science Advisor to Prime Minister of Malaysia

Convenor: Prof. Nidhal Guessoum, Professor of Physics and Astronomy, American University of Sharjah, United Arab Emirates

Co-Convenor and Host: Dr. Mohd Yusoff Sulaiman, President and CEO, Malaysian Industry Government Group for High Technology (MiGHT), Malaysia

Task Force Members:

Dr. Moneef Zou'bi, Executive Director, Islamic World Academy of Science, Jordan

Prof. Adil Najam, Dean, Frederick S. Pardee School of Global Studies, Boston University and former Vice Chancellor, Lahore University of Management Sciences, Pakistan

Prof. Ameenah Gurib-Fakim, Fellow of IAS, President of the Republic of Mauritius, and Professor at University of Mauritius

Prof. Mustafa El-Tayeb, President, Future University, Khartoum, Sudan

Prof. Abdur Razak Dzulkifli, President of International Association of Universities (IAU), and former Vice Chancellor Universiti Sains, Malaysia

Prof. Nadia Alhasani, Dean of Student Life at The Petroleum Institute, Abu Dhabi, United Arab Emirates

Prof. Jamal Mimouni, Professor of Physics, University of Constantine-1, Algeria

Dato Ir. Lee Yee Cheong, Chair ISTIC Governing Board and Chair InterAcademies Panel's SEP Global Council, Malaysia

Task Force on Science at the Universities of the Muslim World

External Experts:

Prof. Michael Reiss, Professor of Science Education, UCL Institute of Education, University College, London

Prof. Bruce Alberts, Professor of Biochemistry, University of California at San Francisco, President Emeritus at the National Academy of Sciences, and Recipient of 2014 US Presidential Medal of Science, United States of America

Dr. Athar Osama, Hon. Senior Associate at UCL Institute of Education, University College, London, and Founder, Muslim World Science Initiative and Project Director of the Task Force on Science at Universities of the Muslim World, Pakistan

Invited Contributor:

Prof. S. Shoaib H. Zaidi, Dean, School of Sciences and Engineering at Habib University, Karachi, Pakistan

The Task Force Members wrote essays in the fall of 2014 and met in Kuala Lumpur on December 15-16, 2014 to discuss and debate issues. A Stakeholders Meeting and an OPEN FORUM was also organised to solicit additional feedback. A number of issues formed an integral part of the task force's agenda and conversations during these meetings and its subsequent deliberations. These include, among others:

- How is science taught in Muslim universities?
- Is there a reasonable balance between the offering of basic science programs and applied science programs? What policy principles govern such choices? Is the Islamic culture a significant/driving factor in these choices?
- Are any science fields or topics avoided for cultural/religious reasons?
- Does any censorship affect science teaching and/or research at universities of the Muslim world? What is the status of academic freedom and how that is understood and applied? Does the Islamic culture play any role in that?
- How do international university rankings influence higher-education policies in the Muslim world?
- What is the state of research funding today in the region? Are the old(er) and the new research funding agencies playing a significant role? What improvements are needed?
- Is scientific research innovative or paradigmatically conservative at universities of the Muslim world? Does one see any inter-disciplinarity/multi-disciplinarity/trans-disciplinarity in scientific research at universities of the Muslim world?
- Are there enough collaborations (regional in particular, but international as well) in scientific projects at universities of the Muslim world?

Task Force on Science at the Universities of the Muslim World

- Is plagiarism in research widespread among scientists in the Muslim world? How can that be addressed? Can Islamic ethical principles be brought to bear to address this?
- Are universities of the Muslim world playing a significant outreach role? How many science blogs are there in the region? How many general-public articles do Muslim scientists write each year? Etc.
- Are universities of the Muslim world helping improve science education at the school level (through involvements with ministries of education, the writing of textbooks, etc.)?
- Are universities of the Muslim world addressing the general science literacy problem in their societies?

The Muslim World Science Initiative Task Forces are funded partly by John Templeton Foundation and the Science at Universities Task Force is brought together with the partnership and support of Malaysian Industry Government Group for High Technology (MiGHT), The Islamic World Academy of Sciences (IAS), and the Akademi Sains Malaysia (ASM).

Universities must reinvent themselves to lead the scientific reforms

“The Task Force is putting out an open call for universities across the Muslim world to join a voluntary Network of Excellence for Science (NEXUS). NEXUS will help build capacity for University Administrators and Champions, monitor the progress of reforms at participating universities, and to issue a peer report card to inspire further improvements.

”



Tan Sri Zakri Abdul Hamid
Task Force Chair and Science Advisor
to the Prime Minister of Malaysia

Foreword

Universities must reinvent themselves to lead scientific reforms in the Muslim World

By: Tan Sri Zakri Abdul Hamid, Chair of the Task Force

Science Advisor to the Prime Minister of Malaysia

It is well-known that the 1.6 billion Muslims of the world contribute an extremely small share to its knowledge. This can be seen in the number of Nobel laureates in the sciences (only three) from the 57 countries with a Muslim majority population (the OIC), in the number of books or patents produced there, or lately in the number of universities from OIC countries in the top 400 of world rankings.¹

Beyond these factoids, there is a widely shared view that science in the Muslim world is significantly lagging. This view is partly based on indicators, including research spending, researchers per million people, performance of pre-university students in science and math, global university rankings, etc.

Overall, OIC countries invest less than 0.5% of their GDP on R&D, and only one country (Malaysia) currently spends more than 1%, while the world average is 1.78%, and most advanced OECD countries spend 2.5-3%.

In terms of pre-university preparation, standardized international tests such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) have shown students from Muslim-majority countries to be well behind their peers worldwide.⁴

Also, until recently, it has been widely accepted, sometimes on the basis of actual data, that science production in the Muslim world (research papers published, invention patents registered, citations of scholarship, etc.) has been largely trailing behind the rest of the world.

It may surprise many, however, that Muslim females are doing quite well in academics but Muslim women hold few professorial positions in the sciences.

What are the causes for this state of affairs,

and what potential remedies can one prescribe to fix that? A review and analysis was warranted and timely.

An international non-governmental and non-partisan Task Force of experts organised by The Muslim World Science Initiative - a private non-partisan group of individuals⁵ - and led by myself recently undertook such a review⁶ and found that several countries have made good progress, at least in terms of research and spending. Still, issues beyond the number of papers and citations became evident, such as how universities of the Muslim world teach and disseminate science, what kinds of scientists were being educated, what is being taught, and what knowledge/curriculum is promoted there for today and tomorrow.

While data was unavailable on several factors, we were able to identify and analyze a number of important underlying themes and issues, focusing particularly on universities, and arrive at essential recommendations that we invite academic administrators and officials within government and academia around the Muslim world to implement.

In particular the following four themes stand out from the review - more detailed treatment of which can be gleaned from the accompany paper and essays:

Research Production: Quantity, Quality, and Content

The Task Force gathered bibliometric data on science production for 20 OIC countries (and five 'comparable' ones) over the last two decades (1996-2005 and 2006-2015) and found interesting results.

The data shows first that all OIC countries have produced more papers in the last decade (2006-2015) compared to the previous one (1996-2005) and, for the more aggressive of these countries, at a rate greater than the peer

countries (see Table 3).

Several OIC countries increased the number of papers published by factors of 7.7 (Qatar), 7.6 (Iran), 6.5 (Pakistan), and 5.8 (Malaysia and Iraq). A few countries have had very modest increases, but most have improved their output by a factor of 2 to 3. Even when normalized for GDP per capita, a few countries (Turkey, Iran, Egypt, Pakistan) reached rather excellent ratios in the second decade. Several others, however, show extremely low results.

Quality is more important than quantity, though; this aspect we assessed through the citation-per-paper ratios. The data suggests that papers from Muslim countries are less frequently cited; furthermore, a recent list by the Journal Nature of the 100 most cited papers had none with a lead author from the Muslim world.⁷

But in addition to being globally competitive, it is critical that scientific research in the Muslim world in general, and at its universities in particular, be of relevance and responsiveness to society's needs (both intellectual and practical). This dual goal seems to be out of sight – and oftentimes even out of consideration – for most academic institutions of the Muslim world.

One approach being adopted by a number of countries in the Islamic world is to bring – in fact almost transplant overnight – foreign universities and ask them to engage in cutting-edge research. King Abdullah University of Science and Technology (KAUST) in Saudi Arabia, the Masdar Institute in United Arab Emirates, and branches of several American universities in Education City in Qatar are such bold new experiments that may be achieving some success, though the jury is still out on their wider impacts and their long-term sustainability. Indeed, these are extremely expensive formulas, largely out of reach for a vast majority of the OIC countries. More modest, organically grown propositions of globally competitive but locally relevant research programmes are the National University of Sciences and Technology (NUST) and the Aga Khan University (AKU) in Pakistan, Sharif University of Technology in Iran, and University Sains Malaysia.

One can notice a correlation between the large increases in research spending that some countries have recently made and the upsurge in research publications. Still, there is much space for improvement for all OIC

countries. Close international collaborations are also recommended in order to strengthen research programs and raise their quality and rigor. Other shortcomings remain, however, particularly with regard to understanding science and its social aspects. Indeed, there is only one university in the entire Muslim world (the University of Malaya) that offers a programme in the crucial discipline of science and technology studies.

More generally, the Task Force noted with alarm that science and engineering curricula in the Muslim world are almost invariably so technically focused that graduates struggle to connect science and technology with the society and the world at large.

Broad liberal education in science

Indeed, one of the main findings of the Task Force is the rather narrow disciplinary focus of science education in most universities of the Islamic world. In most OIC countries, not only are students channeled into science or non-science streams (and thus careers) very early on (around the age of 14), but subsequent education is completely binary: science and technology students receive little general education (humanities, social science, languages, communication, etc.) and vice versa. This prejudices students' development as individuals of diverse and multiple interests and limits their creative potentials.

Indeed, today's scientists and engineers must be creative and innovative and able to work as part of multidisciplinary and multinational teams, and this is only possible if they receive a broad and liberal education. A broad base of knowledge must be built for flexible minds and nimble thinking to emerge in order to intelligently relate the theoretical and practical aspects of a given problem as well as benefit from ideas that can be found in other fields.

Another area of particular weakness within science education in the Muslim world is the almost universal absence of philosophy and even history of science from curricula. This often makes the scientists unable to engage with critical questions that society asks, in terms of ethics, religious issues, purpose and goals of research, etc.

In the last decades, few universities in the Muslim World have attempted to construct curricula where science subjects are taught in relation to the humanities; one such example is Tehran's Sharif University, which is today

highly rated. Recent years, however, have seen the setting up of 'American' liberal-education universities in the region, such as the American University of Sharjah in the UAE, which recently ranked among the Top 10 in the Arab world, and where students are required to take at least one third of their credit-courses in humanities, social sciences, language, and communication, regardless of their chosen disciplines. Conversely, students majoring in non-science fields (business, humanities, etc.) are required to take at least two courses in the sciences.

Habib University in Pakistan is another recent and welcome such example. Adopting the well-tested model of the American-style liberal university, Habib's science and engineering programmes require students to take a rigorous liberal arts core of courses, seeking to create scientists and engineers who can tackle complex, interconnected issues and develop sustainable solutions for society. Students must take subjects like 'Understanding Modernity' and 'Hikma 1 & 2', a two-course sequence that translates as 'Traditional Wisdom 1 and 2', plus many others that seek to create holistic rather than narrow disciplinary professionals.

This is a development that can potentially pay rich dividends in the future and must be looked at carefully by policymakers and university administrators around the Muslim world.

Curricular and pedagogical developments

The Task Force also notes that science textbooks used at universities of the Muslim world are most often imported and used as is from the West, with all the positives and negatives that this entails. Some scientific topics are seen as "controversial" and thus are marginalized; the theory of evolution is usually taught only to biology majors, often as "a theory", and rarely connected to the rest of the body of knowledge. Even biology students in the Muslim world rarely fully comprehend the significance and centrality of the theory of evolution.

Beyond the two vital issues of what must be taught and in what language (English/French vs. local/native languages), the question of how science should be taught is also of critical importance. With few exceptions, science curricula at universities of the Muslim world tend to be heavily loaded, with extensive 'coverage' of topics, instead of aiming for a deeper understanding of how the sciences work and scientists think, and how to analyze problems.

Pedagogical impact and innovation is where the global consensus has moved with regard to science teaching, converging to evidence-based practices. Inquiry-based science education (IBSE) is the new paradigm, and efforts are being made in some Muslim countries to implement this in classrooms. But most universities of the Muslim world continue to lag behind those in the more developed world, where many new initiatives and innovations are currently underway.

There are several reasons for this lag. The lack of pedagogical competence amongst faculty is one of them. Indeed, faculty members are hired with PhDs in their fields; some will have had experience as teaching assistants during their doctoral studies, but rarely – if ever – will they have received any pedagogical training. Another factor compounding the problem is the lack of autonomy for universities, preventing them from innovating in pedagogy and curricula.

Prof. Ahmed Djebbar's programme titled 'Découvertes en Pays d'Islam',¹⁸ which helps teach science ideas by relating to great examples and stories from the 'Golden Age' of Islam is one localised model that could be adopted and replicated across the Muslim world. There are also 'grassroots' efforts across the Muslim world to popularize inquiry-based science education amongst younger students and the general public which operate without much government support but can be built upon and scaled up.

Transforming our universities into meritocracies

In addition to knowledge production and scholarship, one of the main goals and *raison d'être* of universities worldwide is to develop within society a culture of inquiry, intellectual rigor, evidence, and merit. This spirit is what led to and characterized the Muslim 'Golden Age' of science. Hence, whether through knowledge production or science education, universities must not become places where a game of numbers is played (number of papers published, higher ranking achieved, etc.), but rather where a culture of learning is fostered and nurtured – through the incubation of future scientists, thinkers, and citizens – and disseminated through the rest of society.

Transforming our universities into bastions of meritocracy for the benefit of society will require some fundamental re-engineering:

empowering them to do so, holding them accountable for the right objectives, and measuring and rewarding the right things.

Unfortunately, in recent years, in the midst of the rush to “achieve higher results”, some policymakers put in place well-meaning incentives that have led to significant collateral damage. Rewarding people for publications in high impact-factor journals and gauging university competitiveness by rankings alone has created a ‘rent-an-academic’ industry and encouraged plagiarism and junk science. The policymakers whose policies and incentives have distorted university culture and practice must own up to their responsibility and undo the damage.

Quality and merit should be the primary goals driving decision-making in our universities, rather than quantity and deceptive targets. This should apply to administrative as well as curricular and research aspects. Our universities must hire good faculty, fund and support their development as scientists, thinkers, teachers, and communicators, and foster the right values for all to thrive in a complex and competitive world.

Conclusions

The Task Force has made a number of recommendations (see details later) for policymakers and university administrators to benefit from worldwide knowledge and best practices in order to address the significant shortcomings that exist in many places and on several key issues.

The Task Force calls for review and reform of science curricula and pedagogy in the Muslim world using the latest best practices (such as inquiry-based science education), encouraging broad, liberal education with greater multi-disciplinarity, effective pedagogical training of faculty, striving to always be of relevance and service to society, adopting a zero-tolerance policy towards plagiarism, academic fraud, and the perversion of incentives, addressing

the critical issue of language of instruction through research, and engaging science academics, councils, and non-governmental entities to help create inspiring role models for the younger generation – particularly women – to pursue scientific careers.

In order to be effective, reforms may have to be implemented one university at a time. We thus plan to create a Network of Excellence of Universities in Science (NEXUS) in the Muslim world, that will participate in the implementation of the recommendations of the Task Force.

Indeed, without making the tough reforms that aim to make science central to the affairs of Muslim societies, the dream of a scientific revival in the Muslim world will remain just that.

Endnotes

1. See the recent Times Higher Education world university rankings, the QS World University Rankings, or other similar lists.
2. Source: UNESCO Institute of Statistics - http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&popupcustomise=true&lang=en
3. Source: UNESCO Institute of Statistics - http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&popupcustomise=true&lang=en
4. http://timss.bc.edu/timss2011/downloads/T11_IR_Science_FullBook.pdf; <http://www.oecd.org/pisa/keyfindings/pisa-2012-results.htm>.
5. The Task Force contributed essays and collective report can be found at <http://www.muslim-science.com>.
6. Papers and Citations figures from Thomson Reuters ISI Web of Science; GDP figures from: World Bank - <http://data.worldbank.org/>

Preface

“

Universities are the bedrock of the civilisation. It is where new ideas and knowledge gets created. The Muslim World has been home to the oldest continuously operating university in the world. We must work hard to once again recreate the environment for such institutions to flourish. MiGHT is excited to be part of such a noble initiative and to host people of such intellectual calibre. If implemented, the findings of the Task Force truly have the potential to transform the idea of the University in the Muslim world.

”



Mohd Yusoff Sulaiman
Task Force Co-Convenor
President, Malaysian Industry Government
Group for High Technology (MiGHT)

Preface

Dato Dr. Yusoff Sulaiman

*President, Malaysian Industry Government Group for High Technology
& Co-Convenor of the Task Force*

The Task Force on Science at the Universities of the Muslim World is an extremely critical and timely initiative of the Muslim World Science Initiative. The Muslim world today stands at a crossroads. In recent decades, a number of countries of the Muslim world have invested heavily in scientific capacity - particularly universities and their faculties - and have only now begun to emerge from the shadows to which they were condemned to after decades - even centuries - of colonialist exploitation and systematic de-institutionalisation.

The deficit of science in the Muslim world is almost certainly the deficit of institutions and incentives. As the Muslim world's political and economic fortunes declined, the European powers experienced renaissance and enlightenment. This was a period of great institution building in the West as several scientific institutions such as scientific societies, fairs, publishing and peer review, and even corporation were created and refined.

Even though the first University was created by a Moroccan princess Fatima al-Firhi, the European powers were better able to exploit its true potential when they created the Oxfords and Cambridges of this world that these still stand tall today for their scientific productivity and intellectual climate. As the Muslim world lagged behind first in creating and then renewing these institutions, predictably its fortunes declined.

Today, as countries of the Muslim world invest in creating and strengthening these institutions, the role of the university as the bedrock of any civilisation is paramount to the future of the Muslim world.

Today, more than ever before, the Muslim world is in need of a transformation of its universities into intellectual powerhouses of ideas - new and old - platforms for a free and vigorous debate, critical inquiry and freedom of thought and expression, and bastions of metrocracy within their respective societies.

At Malaysian Industry Government Group for High Technology (MiGHT) we are very pleased to have hosted such a august gathering of scholars and intellectual leaders who have come forward and lent their ideas as well as names to an audacious goal of transforming the 'idea of the university' in the Muslim world.

I am confident that the report of the proceedings of this group and its recommendations to science and university leaders around the Muslim world shall provide the critical blueprint of the kind of reforms needed and how to undertake them.

I am certain that this group is as good as - if not better than - any other ever assembled in the Muslim world to execute upon such an ambitious target.

I look forward to working with the members of the task force and hosting the proposed Network of Excellence of Universities for Science (NEXUS) in the years to come.

We will - inshaAllah - one day see the universities playing their part in bringing about a scientific revival of the Muslim world.

Mohd. Yusoff Sulaiman
Malaysia.

Report of the Task Force on Science at Universities in the Muslim World

Executive Summary of Findings and Recommendations

The State of Science at Universities of the Muslim World

Universities are the bedrock of a knowledge society. In the developed world, these have evolved over hundreds of years into institutions that specialize in creating and disseminating knowledge. In the Muslim world, and particularly the Arab world, universities are a relatively recent phenomenon: three quarters of all Arab universities were established in the last 25 years of the 20th century.¹

However, recent considerations (summarized below) have made a review of the status of Muslim-world universities (institutional structure and level of success in the production, transmission, and dissemination of knowledge, etc.) important and timely.

Indeed, there is a widely shared view that science in the Muslim world is significantly lagging. This view is mostly based on indicators such as: research spending levels, numbers of researchers per million people, performances of pre-university students in science and math, global university rankings, etc.

For example, no universities of the Muslim world can be found in the top 100 of the various international rankings that have appeared in recent years; in fact, only a dozen or so can be found in the top 400. Likewise, Muslim pre-university students have performed well below their peers in standardized international tests of science and mathematics (TIMSS and PISA, see below), and their scores have further declined lately.

Research spending, while having slightly picked up in recent years, is still dismal: overall, OIC countries invest less than 0.5% of their GDP on R&D, and only one country (Malaysia) currently spends slightly more than 1%, while the world average is 1.78%, and most advanced OECD countries spend 2.5-3%. For various reasons, including the above, a 'Task Force' was assembled about

a year ago, presided over by Tan Sri Zakri Abdul Hamid, the Science Advisor to the Prime Minister of Malaysia, and included a dozen members with vast experience in the field from around the world.

The main purpose of the task force was indeed to review the state of science at universities of the Muslim world, and if the "poor" assessment is confirmed, determine the institutional flaws and make recommendations to fix them.

General Assessment

The 2014/2015 edition of the Times Higher Education world university rankings had only 10 universities from the Muslim world in the top 400 (Middle East Technical University, Turkey, at 85, three universities between 139 and 182, one between 200 and 300, and five between 300 and 400). In the most recent QS World University Rankings, no university of the Muslim world was in the top 100, and only 17 ranked among the top 400 (University of Malaya, Malaysia, at 151, 5 were between 225 and 300, and 11 between 300 and 400). One may also note that most of these universities have improved their rankings significantly in recent years, with some critics raising allegations of "playing the rankings game".

It is worth noting that these rankings have been criticized on various grounds, particularly the lack of contextualization in the ranking process and the exaggerated emphasis on research productivity at the expense of the teaching and the human development missions of universities. However, an effort by the OIC² to create its own rankings failed to reach a consensus on the criteria by member countries.

Another source of concern about the production of science in the Muslim world is the percentage of the GDP spent on research and development (R&D). As mentioned above, OIC countries invest significantly less than the

world average. To give a few striking examples: as of 2010-2012, Saudi Arabia is spending 0.07 %, Kuwait 0.10 %, Indonesia 0.10 %, Pakistan 0.40 %, Egypt 0.42 %, Jordan 0.43 %.³

Likewise on the number of researchers per million of population: UNESCO data show an average of about 600 for the OIC countries, and only Tunisia and Malaysia present solid and increasing numbers, at about 2,000. Reasonable comparisons may be made with Brazil (1,000), Spain (4,000), and Israel (9,000).⁴

Other worrisome data are the performance of pre-university students from the Muslim world in standardized international tests of science and math. Indeed, there is no data on university student performance in science, as students do not take any standardized exit exams, nor any GRE-type exam when enrolling in MSc and PhD programs.

Pre-university, however, 18 Muslim-majority countries have participated in the TIMSS (Trends in International Mathematics and Science Study) test, and 8 countries have taken part in PISA (the Programme for International Student Assessment). These standardized tests are given every few years: TIMSS tests Grade 4 and Grade 8 students in Math and Science, and PISA tests 15-year-old students in Math, Reading, and Science.

Reviewing the scores of the Muslim countries that have participated so far in either test, one finds that they all have fared very poorly, scoring well below average, sometimes alarmingly so (see Tables 4 and 5 in the Task Force's main report). Furthermore, looking longitudinally, over the past decade or so, one finds no progress at any grade, except for Qatar, Turkey, and to some extent Iran, though they all have remained well below average. In fact Jordan and Malaysia register considerable declines.

Finally, and until recently, it has been widely understood, sometimes on the basis of actual data, that science production (research papers published, invention patents registered, citation of works by others around the world, and technology exports, etc.) in the Muslim world has been largely trailing behind the rest of the world.

Scientific Research Production

The first task that the Task Force thus undertook was to gather bibliometric data on science production over the last two decades, 1996-2005 and 2006-2015, aiming to assess progress or lack thereof.

Five "comparative countries" were selected for more "reasonable" evaluations: Brazil, Israel, Spain, South Africa, and South Korea. These represent countries with similar GDP per capita to average or typical countries of the OIC⁵ or states that Muslim-world countries should seek to emulate and reach in terms of educational and socio-economic progression that they have made in recent years.

Table 3 shows the scientific research output of 20 countries of the Muslim world and that of the 5 peer countries. The data has been obtained using the internationally reputed Thomson Reuters ISI Web of Science database, a rather stringent and high-threshold database of scientific research.

Over 1996-2005 and 2006-2015, the following indicators were compared: a) the number of papers produced in science fields (excluding all engineering and medical fields); b) the number of papers divided by the GDP per capita of each country; c) the citation figures per paper, as a measure of the quality of the scientific research.

A number of interesting conclusions can be drawn:

First, all countries have produced more papers in the more recent decade (2006-2015) compared to the previous one (1996-2005). In fact, several Muslim countries have achieved striking increases: by factors of 7.7 (Qatar), 7.6 (Iran), 6.5 (Pakistan), and 5.8 (Malaysia and Iraq). A few countries have had much more modest increases, but most have improved their output by a factor of between 2 and 3.

But financial resources are an important determinant in a country's ability to produce scientific research at international standards: the ability to buy equipment, to competitively attract and retain scientists of high competence, etc. We have thus "normalized" the numbers by dividing them by the GDP per capita for each country (richer countries should be able to produce proportionately more papers).

Except for Israel, which scores surprisingly low on this metric, our comparative countries achieve ratios between 8 and 20 in the first decade, and 6.5 to 15.7 in the second decade. The best Muslim countries (Turkey, Iran, Egypt, Pakistan) have somewhat lower ratios (between 7.6 and 10.4) in the first decade, but reach rather excellent ratios in the second decade; 16.6 for Iran and 25.2 for Pakistan. Several other countries, however, show extremely low results.

The citation-per-paper ratios, for each country and in each decade, are meant to measure the quality of the research produced in each case. The peer countries achieve ratios of 18 to 31 in the first decade and 10 to 14 in the second decade (papers published more recently will not have had as much times to be cited often).

Papers from Muslim countries may at first sight appear to be of somewhat lower quality: citation-by-paper ratios of about 10 to 20 (compared to 18 to 31) in the first decade and 5 to 8 in the second decade (compared to 10 to 14). However, other factors may be at play: inability for many researchers of the Muslim world to publish in high-quality journals, simply due to page charges, which universities pay in the west but those in the Muslim world often cannot afford to; papers from "obscure" universities sometimes are not given the attention they deserve by colleagues in western universities; etc.

All in all, the figures seem to be rather reasonable and encouraging for several – but not all – countries of the Muslim world.

The above data, while useful in giving a quick view of the state of scientific research in the Muslim world, does not cover all aspects of the subject. For instance, it does not tell us whether the research is innovative, collaborative (nationally, regionally, or internationally), primarily geared toward local needs or contributes more to the global body of knowledge, what role it plays in the university system; etc.

Furthermore, scientific research output, as expressed by the indicators examined above, is one typical way of measuring science productivity in a country or at a university, but it is not the only one. However, when assessing the state of science as a whole at a

university or in a country, other indicators may be considered.

One such indicator is the student enrollment figures in science fields, at both undergraduate and graduate levels. The data (Table 6) shows large variations from one country to another, and often times from one year to another. To put things in perspective: in Brazil, it was 6.0 % most recently; in India, it was 16.6 %, and in the UK, it has been quite steady at about 14 %. In Egypt it is surprisingly low at 4.3 %; in Iran it seems to have been dropping (from 13.3 % in 2000 to 7.3 % in 2012), likewise in Malaysia (from 19.4 in 2005 to 11.2 % in 2012). In some Muslim countries, the percentages are quite high: around 20 % in Morocco, and around 15 % in Saudi Arabia.

We may also consider female to male tertiary enrollment ratios in science fields. The most recent (2010 or 2012) UNESCO data shows women from OIC countries strongly present in science fields (ratios ranging from 44 to 69 %). For comparison, the ratios were: 25 % in Brazil, 30 % in Spain, 40 % in Korea, and 40 % in the United Kingdom.

Now, even though significant numbers of women study science, there is little data on whether they actually take up science as a profession, though there is some indication (from the number of female university professors, for instance), that few Muslim women end up in scientific careers.⁶ However, one may consider the percentages of female researchers: the most recent data (2010 or 2012) suggests that most Muslim countries have female fractions that are at least comparable to the world average (about 30 %): the lowest was Iran at 27 %, the highest was Malaysia at 49 %, compared to South Africa's 40 %, and Spain's 38 %.

The Teaching of Science at University of the Islamic World

Various types of data pertaining to universities and science in the Islamic world are currently unavailable, particularly with regard to the teaching of science. Issues that require some systematic reviewing include: curricula (what is taught); pedagogy (teaching methods); language issues (which languages are used in the teaching of science, i.e. the local one or English/French and what impact each option

has on student learning); (self-)censorship (e.g. "sensitive topics" such as Darwinian evolution); etc.

In aiming to raise the quality of its "products", universities must strive to continuously improve the teaching that is delivered, especially at the undergraduate level. For instance, senior professors should be strongly encouraged to teach at the lowest levels of the curriculum, particularly the foundational courses, bringing to bear their many years of learning and experience.

In its deliberations, the Task Force stressed the importance of the pedagogical competency of the professors who teach various science subjects. It was noted that university faculty are hired with a PhD in their fields, but often with little or no teaching experience, and rarely – if ever – does any pedagogical training take place. Thus, pedagogical (re)training of science professors is a must, with a special emphasis on new instructional technology and tools which have recently been shown to be highly effective. A general consensus has emerged on the need to adopt IBSE (inquiry-based science education) as a general approach, at all levels.

Another important pedagogical issue is the typically heavy syllabi that are found in science courses throughout the region; less "coverage" is strongly recommended, particularly in first-year courses at the university and in pre-university schools and colleges.

Thirdly, the dearth of internship programs for science majors has been noted. An adoption of service learning and project-based learning is needed for a full appreciation and mastery of both the scientific method and various applications in the local context and environment. Internships can be difficult to organize and run, but if done right, their "return on investment" can be very high.

Fourthly, a balance must be achieved between the offering of basic and applied science programs. At universities of the Muslim world, and perhaps more widely across the developing world, a disconnect between the two is often observed. Students are forced to choose either pure science and get little exposure to design, engineering and applied subjects, or they go into applied fields and get "shielded" from their theoretical contexts. This is not a recipe for progress and success. Scientists and engineers

can only be creative and innovative if they have as broad a base of knowledge as possible and flexible minds that can relate to the theory and fundamentals of a given problem, see its application or context clearly, and make good use of that.

Last but not least, curricula should be more "rounded", i.e. contain enough general education (humanities, social science, languages, communication) to ensure that science graduates in the Muslim world are not technically competent at the expense of broader knowledge.⁷ The latter, it is widely agreed, gives scientists and engineers new perspectives, thus more creativity in solving various problems, and helps them collaborate and communicate better with colleagues, superiors, officials, and the public at large. At the very least, curricula for basic-sciences programs should include humanities courses related to science, e.g. history and philosophy of science.

Prof. Zou'bi, the Director General of the Islamic world's Academy of Sciences and a member of the Task Force, has also noted the dearth of Science and Technology Studies (STS) programs in the Islamic world. This means that universities produce few if any policymakers and experts who could even critically evaluate the state of science and science education in the Islamic world.

The Task Force also notes, unhappily, that universities of the Muslim world do much too little in terms of outreach. In the absence of involvement of professors and scholars in educating the general public, society is left with unqualified people addressing the public on subjects that they have no expertise on. This has sometimes translated into misinformation that led to confusions and panics (as in the case of earthquakes, eclipses, epidemics, etc.).

Unfortunately, outreach is generally seen as a marginal activity at universities, with little recognition accorded to it, compared to academic publications, despite their varying quality. Outreach must be considered as an important form of service (along with teaching and research) in the duties of faculty members. Perhaps awards for significant outreach activity could be instituted to encourage professors to partake more vigorously in this endeavor.

Finally, a word must be said about the university reforms that have been undertaken in some Muslim countries recently. In Pakistan, the Higher Education Commission has invested heavily in creating new universities, upgrading existing ones, and funding thousands of PhD scholarships for faculty development. In Qatar, an Education City was created with several foreign universities, in an effort to raise standards, both cooperatively and competitively. In Saudi Arabia, several new universities have been created, particularly the King Abdullah University of Sciences and Technology (KAUST), in addition to significant investments in the existing ones. Malaysian universities have also undergone upgrades, with the creation of an elite class of research universities. In the UAE, a number of new academic institutions have missions focusing on science, technology, engineering, and mathematics (STEM), such as Masdar Institute of Science and Technology, Khalifa University of Science, Technology, and Research, The Petroleum Institute, etc.

No studies have yet been undertaken to assess the effect of these reforms, and indeed while it is perhaps too early to fully measure their long term impact, interim evaluation is warranted.

Conclusions and Recommendations

First, the Task Force calls for extensive data on universities of the Muslim world, both cross-sectional and longitudinal, to be produced on: faculty profiles, curricula, pedagogy, language of instruction, science graduates, employment rates, etc. This is a task that official (preferably trans-national) bodies, such as the Islamic world Academy of Sciences (IAS) or the Islamic Educational, Scientific and Cultural Organization (ISESCO), must undertake and make publicly available for use and analysis.

The Task Force makes 10 recommendations divided into 3 sections/areas, according to the major audiences being addressed:

A1-A4 for academic institutions (universities, schools, etc.);

B1-B3 for national policymaking and implementation institutions (e.g. Ministries)

C1-C3 for key stakeholders (Academies of science, industry, civil society, etc.);

A) Recommendations for Academic Institutions:

A1) Rethink science curricula at universities (i.e. 'what should be taught?')

- **Adopt a broad-based, general-education curriculum** for students majoring in all science and engineering disciplines. Complement students' technical education by adding humanities topics of direct relevance to science (Philosophy of Science, History of Science, Ethics of Scientific Research, etc.), basic social sciences, and communication skills (languages and verbal and written communication).

- **Re-orient universities towards their student-centric missions:** create endowment funds for students who might be prevented from pursuing science majors due to lack of financial means; improve the capacity of graduate programs to attract talented students by addressing issues such as attrition rates, time to degree, funding, and alignment with student career opportunities and national interests; etc.

- **Encourage multi-disciplinarity in training as well as in the choice of courses for science majors,** such as connecting science programs with both engineering and social science programs.

- **Implement internships in science fields for students at the end of their junior year,** allowing this experience to be incorporated in final (senior-year) projects (link with industries and local community companies, research institutions, etc.).

- **Engage undergraduates in faculty research to give them early exposure** to how scientists think, formulate problems, and create and implement strategies to solve them.

A2) Adopt effective teaching pedagogies for science (i.e. 'how should it be taught?')

- **Adopt IBSE/Active-Learning teaching methods,** e.g. "clickers", group learning setups, and other approaches that develop critical thinking, e.g. analyzing science papers from the literature, newspaper articles about scientific topics, etc.

- **Adopt and popularize the notion of Discipline-Based Education Research**

(DBER) in creating, experimenting with, and delivering science instruction in the classroom .

- **Re-train the faculty on modern and new pedagogical approaches** that develop in students creative thinking, critical inquiry, and rejection of “the argument from authority”.

- **Enable and encourage faculty members to use modern technological tools**, such as new media approaches, learning management systems, simulations, etc. for a better and more enriching learning experience and to make science instruction fun, where possible.

- **Develop contextualised curricula** by enabling and encouraging faculty members to develop new courses, write textbooks and develop curricula that take into account local conditions and contexts.

A3) Transform universities into meritocracies (i.e. ‘hire, incentivize, and empower’)

- **Attract quality faculty – particularly expats – and create productive networks around them.** Universities (and departments), it is said, are built around individuals not physical assets or buildings. Muslim expats living and working in the West could be a starting point for such an exercise. Several high-income Muslim countries such as those in Persian Gulf and South East Asia should be able to do even better.

- **Provide intellectual and administrative autonomy, freedom of thought and expression, and the ability to pursue one’s interests.** People in academia self-select to a life of relative autonomy and freedom, and this forms a very critical part of their intrinsic motivation system.

- **Support faculty research through ‘early career grants’ and ‘merit-based competitive research grants.’** This could be done through endowment funds or partnerships with industry actors. Even if the amounts are small, they provide an impetus, the first exposure, and a foothold on which to build one’s independent research career and serve as starting points for young faculty to go out and raise more money.

- **Support Pedagogical Innovation through an institutional small grants programme focused on curricular and**

pedagogical innovation. These grants could be used to fund faculty time to develop such approaches, attend training programmes, or buy equipment needed to implement new approaches.

- **Institute a system of rewards, recognition, and promotion that measures faculty performance in teaching, research, and outreach.** Rewarding and recognizing quality teaching – ideally through the promotion system – is critical to ensuring that faculty will spend time and effort to be better at it. Recognition (through teaching awards, for instance) is one important way to encourage faculty to focus serious attention and time on this essential university mission.

A4) Revive the universities’ social contract with society (i.e. ‘relevance and service’)

- **Connect universities to schools** – primary, secondary, and high schools – to ensure conceptual and curricular continuity.

- **Create public outreach and science engagement programmes** that enhance the citizen’s engagement with and appreciation of science and the scientific method.

- **Ensure that STEM curricula make reference to national and social agendas**, e.g. health and medical programs (obesity and diabetes epidemics, cancer prevention and detection, etc.).

The Task Force invites interested universities from around the Muslim world to engage, substantively, in a conversation around the above set of recommendations and seeks nominations by a ‘coalition of the willing’ to endorse and adopt these recommendations and become partners in an “implementation programme” presented below.

B) Recommendations For national policymaking and implementation institutions (such as Ministries):

B1) Provide greater autonomy and flexibility to universities for:

- **Designing innovative curricula and research programs**, and supporting a

pedagogical innovation fund

- **Relaxing often cumbersome and restraining regulations** so as to enable universities to transform themselves into meritocracies that reward performance. Define career paths that young scientists find meaningful, attractive, and challenging.

B2) Support a university culture of accountability, evaluation, and best practices:

- **Produce extensive data** (for as many universities as possible, cross-sectional and longitudinal) on science graduates, curricula, pedagogy, languages of instruction, as well as employment rates and work profiles of science teachers/faculty, science graduates, etc.

- **Improve the quality of higher education regulation and certification, and adopt a zero tolerance policy towards academic fraud.** Consider effective mechanisms of signaling quality, where market information fails to do, such as national and regional rankings of institutions with similar missions, setting up information clearinghouses, etc.

- **Engage with academies of sciences, where possible, to create oversight panels** that ensure that quality science education is delivered.

B3) Address national policy issues in a timely and effective manner.

- **Ensure sustained funding for higher education institutions** that approach international norms (about 20-30 % of all government spending on education). The higher education spending should also include funds for development and research. The funding policy may encourage, through inducement and incentives, universities to gradually raise endowments to support faculty research and student scholarships.

- **Address the issue of the language of instruction by undertaking rigorous research on the question and examining the pros and cons of various propositions (bi-lingual, etc.).** In parallel, create national science translation projects to ensure the availability of up-to-date scientific content in national languages, including articles, special issues, and books on science education

- **Adopt and implement a full-system approach to enhancing STEM education within the society**, by ensuring that what is taught within schools is well-integrated with university curricula. Develop consistency in both what is taught (syllabus) and how it is taught (pedagogy) throughout the educational continuum. Conduct re-training workshops for science teachers to bring them to date with new tools and knowledge.

C) Recommendations for Key Stakeholders (science academies, industry, civil society, etc.)

C1) To enable important stakeholders within the society to constructively engage with universities:

- **Create greater linkages between academies of science and university programs** to ensure currency in terms of content and pedagogical approaches.

- **Establish multi-stakeholder advisory boards and curricular committees for each science program**, bringing together educators, policymakers (administrators, officials), business and industry leaders, and other civil society actors.

- **Create Science-to-Action councils** at every university to engage scientists and science students in tackling local problems and challenges.

C2) To enhance the national profile of sciences and STEM careers:

- **Encourage students to take part in international competitions and scholarships**, such as Intel Science and Engineering Fair (ISEF), the International Science Olympiads, the Meetings of Nobel Laureates, etc.

- **Engage the media in its various forms** in promoting scientific culture, values, and role models within the society.

- **Popularize science and provide routes for the successful commercialization of its relevant discoveries.**

C3) Enhance the representation within STEM of minorities:

- **Involve youngsters in the dynamics of science**, e.g. by creating and supporting national and regional young academies of science along the lines of Pakistan's National Academy of Young Scientists (NAYS), the Arab World Academy of Young Scientists (ArabWAYS), etc.

- **Stress gender neutrality of science** by highlighting, in equal measure, bright examples of scientific success among young women (and men). Create special programmes to attract young women to STEM education and STEM careers, where such a deficit exists.

Next Steps: NEXUS

The Task Force is convinced that an official response to the challenge of reforming the university in the Muslim shall remain inadequate and that a bottom up – rather than top-down – approach is warranted.

A reform movement that creates a few examples of excellence among universities in the Islamic world could have a powerful demonstrative effect on other universities who may be inspired to replicate such success.

The Task Force is thus seeking to create a Network of Excellence of Universities for Science (NEXUS) to help advance this bottom up and peer-driven reform agenda forward. This NEXUS of self-selected institutions shall be the primary vehicle to take the ideas of the Task Force forward.

Managed by the Muslim World Science Initiative and the Task Force and housed at Tan Sri Zakri's Office, NEXUS shall provide advice and support to universities that endorse the recommendations of the Task Force and pledge to make progress in gradually implementing them.

We plan to build capacity by running a summer school for university administrators, to monitor the progress of reforms at participating universities, and to issue a peer report card that will

assess the performance of the participating universities in meeting milestones, thus recognizing progress and inspiring further improvements.

The Task Force invites Universities from across the Islamic World aspiring to become part of this network to join hands to reinvent themselves and lead the change within the broader society.

Endnotes

1. N. Fergany et al., Arab Human Development Report 2003, p. 56, available here: http://hdr.undp.org/sites/default/files/rbas_ahdr2003_en.pdf

2. The other members of the Task Force were, in alphabetical order: Bruce Alberts (Professor of Science and Education, UC San Francisco; former president of the US National Academy of Sciences); Nadia Alhasani (Dean of Student Life, The Petroleum Institute, Abu Dhabi, UAE); Lee Yee Cheong (Chair ISTIC Governing Board, Chair IAP SEP Global Council); Abdur Razak Dzulkifli (former Vice Chancellor of the University Sains Malaysia); Mustafa El-Tayeb (Vice Chancellor, Future University, Sudan); Ameenah Gurib-Fakim (Biodiversity Scientist and, since recently, President of Mauritius); Jamal Mimouni (Professor of Physics, University of Constantine, Algeria); Adil Najam (Professor, Boston University and former Vice Chancellor, Lahore University of Management Sciences, Pakistan); Michael Reiss (Professor of Science Education, University College London, UK); Moneef Zou'bi (Executive Director, Islamic Academy of Sciences).

3. The OIC stands for 'Organization of Islamic Cooperation', the international organization which was founded in 1969 and consists of 57 member states, most of which are Muslim-majority countries.

4. Source: UNESCO Institute of Statistics - http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_popupcustomise=true&lang=en

Report of the Zakri Task Force on Science at the Universities in the Muslim World

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Task Force Strongly
believes that the most appropriate venue for
action on our recommendations is the uni-
versity itself. The most essential ingredient
in creating excellence in science and
science teaching at a university is a realiza-
tion, within a university's highest leader-
ship and its faculty, of the need to give up
the old and dated ways, renew the purpose,
and re-write the genetic code of their uni-
versity.

”



Nidhal Guessoum
Task Force Convenor
Professor of Physics and Astronomy
American University of Sharjah, UAE

Report of the Zakri Task Force on Science at Universities of the Muslim World

By: Nidhal Guessoum¹ and Athar Osama²

¹*Professor of Physics and Astronomy, American University of Sharjah, UAE
& Convenor of the Task Force*

²*Hon. Senior Associate, UCL Institute of Education, University College, London
& Project Director of the Task Forces Initiative*

The State of Science in the Muslim World

Science, or more generally knowledge, has always occupied a high place in the Islamic culture. As Muhammad Abdus Salam, the first person from the Islamic World to receive a Nobel Prize in the sciences, often remarked, some 750 verses of the Qur'an (about one sixth of the Holy Book) describe natural phenomena and encourage Muslims to explore and reflect upon them.

Moreover, the 1,000-year history of the Islamic civilization contributed tens of thousands or perhaps hundreds of thousands of manuscripts in various science subjects as well as countless discoveries, inventions, and innovations. For example, astronomical observatories were built from the early ninth century to the late sixteenth century in an unprecedented display of very large instruments (e.g. the 40-meter-radius Fakhri sextant at the Samarkand observatory), rich libraries (400,000 books at the Maragheh observatory), and research staff (the Istanbul observatory had at least 15 full-time astronomers, some of them coming from "abroad"), etc.¹

Many fields of science were revolutionized or pioneered by Muslims: Algebra by Al-Khwarizmi, Optics by Ibn al-Haytham, Astronomy by Nasir Uddin Al-Tusi, Geology and Mineralogy by Al-Biruni, Medicine, Surgery, and Pharmacology by Ibn Sina, Al-Zahrawi, Ibn Zuhr, Ibn al-Baitar, and many others.

A long period (several centuries) of decline followed that glorious era due to a number

of reasons that are beyond the scope of this report. By the middle of the twentieth century, however, large parts of the Muslim world were emerging from a dark period of colonial rule, which left the Muslim population largely uneducated and without vital infrastructure (for education and other important dimensions of modern life), and national governments had to scramble to restart the engine of socio-economic progress. This required building a solid educational system up to and including universities and research institutions, at least to support the development programmes that were being implemented.

Fifty years or so later, however, the state of science in the Muslim world is widely seen as "poor", as it trails behind the rest of the world on several indicators, such as the fraction of the Gross Domestic Product (GDP) that is spent on scientific research and development, world university rankings, the fraction of the population working as scientists/researchers, the performance of pre-university students in math and science, etc.

Universities are the bedrock of a knowledge society. In the developed world, these have evolved over hundreds of years into institutions that specialize in creating and disseminating knowledge. In the Muslim world, and particularly the Arab world, universities are a relatively recent phenomenon: three quarters of all Arab universities were established in the last 25 years of the 20th century.² However, recent considerations (below) have made a review of the status of universities in the Muslim-world (institutional structure, the degree of

¹ See N. Guessoum, "Time for an Arab astronomy renaissance", *Nature*, 498:7453, pp. 161-164 (2013).

² N. Fergany et al., Arab Human Development Report 2003, p. 56: http://hdr.undp.org/sites/default/files/rbas_ahdr2003_en.pdf

success in the production, transmission, and dissemination of knowledge, etc.) important and timely.

In addition to knowledge production and scholarship, one of the main goals and *raison d'être* of universities worldwide is to develop within society a culture of inquiry, intellectual rigor, evidence, and merit. This spirit, the Task Force recalled, is what led to and characterized the Muslim 'Golden Age' of science. Thus, a survey of the performance of universities of the Muslim world in science (production, teaching, dissemination through society) is an important element in our effort to gauge our progress (or lack thereof) and to prescribe remedies to steer the Muslim world toward greater socio-economic and cultural development.

To begin exploring the state of science at universities of the Muslim world, one may perform comparisons on some of the above-mentioned indicators between individual countries, as well as the 57 OIC³ member countries as a group, with a few comparable "peer" countries. We selected: Brazil, Israel, Spain, South Africa, and South Korea for this comparison.

Table 1 - Population and GDP of Select Peer Countries for Comparison⁴

Country	GDP per Capita (\$)	Population
Brazil	15,037	200,000,000
Israel	32,760	8,000,000
South Africa	12,507	53,000,000
South Korea	33,140	50,000,000
Spain	32,925	46,600,000
OIC Average	10,825	26,300,000
World	14,400	36,200,000

These are countries with similar GDP per capita to average or typical countries of the OIC (see Table 1); these are also states that

countries in the Muslim-world should seek to emulate and reach in terms of the educational and socio-economic progress that they have made in recent years.

Furthermore, and though on several indicators, longitudinal (time-sequenced) data is rarely available for most Muslim-world countries, we have striven to obtain and show time trends (of at least a decade or more), where possible. .

For example, looking at some of the global university rankings that have appeared in recent years, one finds universities of the Muslim world not having ranked highly. One must note that these rankings have been criticized on various grounds, particularly the lack of contextualization in the ranking process and the exaggerated emphasis on research productivity at the expense of the teaching and the human development missions of universities, their use as a signal of quality or an instrument of policy has caught on even though they may only be partial or imperfect indicators of the competitiveness of a university. There have also been allegations that the criteria used by these rankings do not do justice to universities in certain regions, such as the developing or the Muslim worlds. However, an effort by the OIC to create its own rankings failed to reach a consensus by member countries on the criteria that should be adopted.

In the 2014/2015 edition of the QS World University Rankings, no university of the Muslim world was in the top 100, and only 17 ranked among the top 400 (University of Malaya, Malaysia was highest at 151, 5 were between 225 and 300, and 11 between 300 and 400) – see Table 2a. Similarly, the most recent Times Higher Education world university rankings had only 9 universities from the Muslim world in the top 400 (Middle East Technical University, Turkey, at 85, 3 universities between 139 and 182, 1 between 200 and 300, and 4 between 300 and 400) – see Table 2b. One may note that most of these universities have dramatically improved their rankings in recent years, inviting some critics to allege that they are "playing the rankings game".

³ The OIC stands for 'Organization of Islamic Cooperation', the international organization which was founded in 1969 and consists of 57 member states, most of which are Muslim-majority countries.

⁴ Source: IMF and World Bank, 2012.

Table 2a – List of Muslim world universities in the
Top-400 of the QS World University Rankings⁵

Ranking within OIC	Ranking the World	in	University	Country
1	151		University of Malaya	Malaysia
2	225		King Fahd University of Petroleum and Minerals	Saudi Arabia
3	249		King Saud University	Saudi Arabia
4	249		American University of Beirut	Lebanon
5	259		Universiti Kebangsaan Malaysia	Malaysia
6	294		Universiti Teknologi Malaysia	Malaysia
7	305		Al-Farabi Kazakh National University	Kazakhstan
8	309		Universiti Sains Malaysia	Malaysia
9	310		University of Indonesia	Indonesia
10	324		L.N. Gumilyov Eurasian National University	Kazakhstan
11	334		King Abdulaziz University	Saudi Arabia
12	360		American University of Cairo	Egypt
13	376		Universiti Putra Malaysia	Malaysia
14	385		United Arab Emirates University	UAE
15	390		American University of Sharjah	UAE
16	399		Bilkent University	Turkey
17	399		Bogaziçi University	Turkey

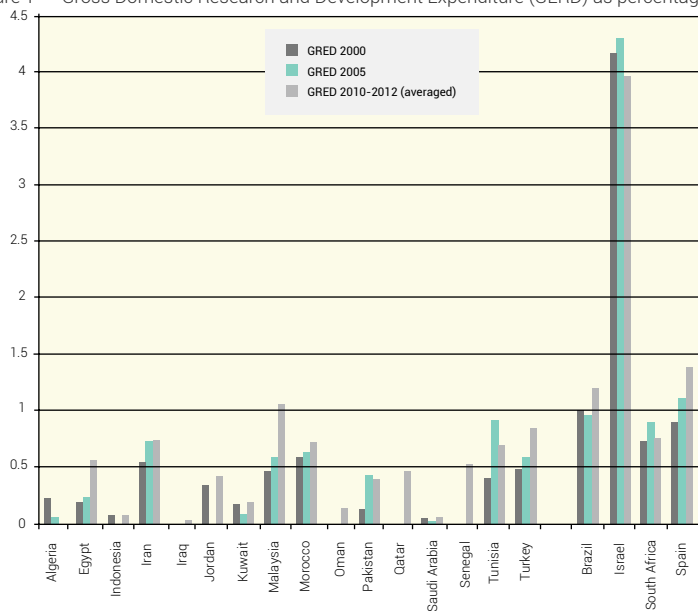
Table 2b –List of Muslim world universities in the Top-400 of the Times Higher Education World University Rankings⁶

Ranking within OIC	Ranking in the World	University	Country
1	85	Middle East Technical University	Turkey
2	139	Bogaziçi University	Turkey
3	165	Istanbul Technical University	Turkey
4	182	Sabanci University	Turkey
5	201-225	Bilkent University	Turkey
6	301-350	Koç University	Turkey
7	301-350	University of Marrakech Cadi Ayyad	Morocco
8	301-350	Sharif University of Technology	Iran
9	351-400	Isfahan University of Technology	Iran

⁵ Source: <http://www.topuniversities.com/university-rankings/world-university-rankings/2014>

⁶ Source: <https://www.timeshighereducation.co.uk/world-university-rankings/2015/world-ranking>

Figure 1 – Gross Domestic Research and Development Expenditure (GERD) as percentage of GDP (%)*



*SOURCE: UNESCO Institute of Statistics and UNESCO Science Report (2015)

Only two universities appear in both the lists (namely: Bogaziçi University and Bilkent University, both in Turkey). Indeed, the two rankings use somewhat different methodologies in assessing universities around the world. The Times Higher Education system is based on 13 criteria that are grouped in 5 categories: Teaching (30% of the final score), research reputation and production (30%), citations of research (32.5%), fraction of international staff and students (5%), industry income (2.5%). Clearly this methodology privileges research-intensive universities; indeed, even in the Teaching category, PhD awards count for 6%. The QS rankings system is based on six indicators: academic peer review, i.e. institution's reputation among academics worldwide (40%), faculty/student ratio (20%), citations per faculty (20%), reputation of graduates among employers (10%), and fraction of international staff and students (10%). This then gives quantitative measures of research less importance but accords the fuzzier "reputation" criterion a much larger weight.

Another important indicator of the state of science in the Muslim world and a source

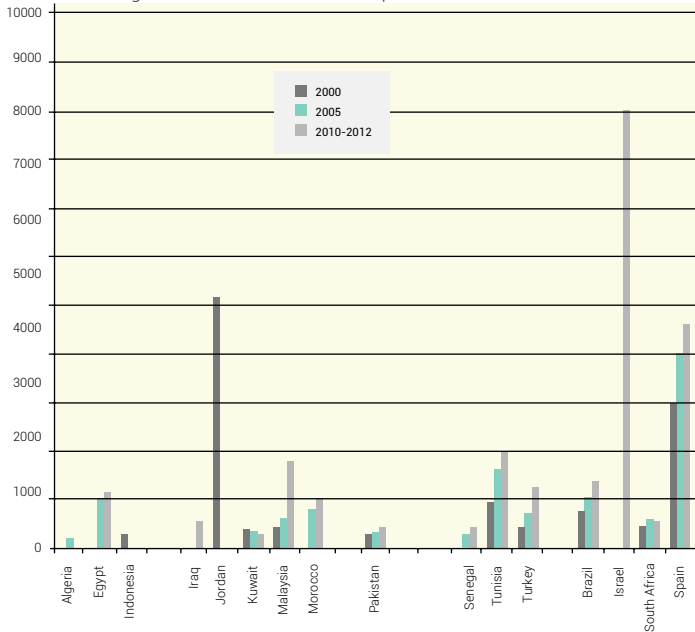
of concern is the percentage of the Gross Domestic Product (GDP) spent on research and development (R&D). As a whole, OIC countries invest less than 0.5% of their GDP on R&D, with only one country (Malaysia) currently spending slightly more than 1% of its GDP on research and development, the world average being 1.78%, and most advanced OECD countries spending 2.5-3%.

To give a few striking examples: as of 2010-2012, Saudi Arabia was spending only 0.07%, Indonesia 0.08%, Pakistan 0.40%, Jordan 0.43%, Iran 0.75%. Among our peer countries, Brazil, South Africa and Spain spend about 1% each, while Israel has maintained its R&D expenditure at about 4% for many years.

A few countries have made substantial efforts (increases in the research budget) in recent years, but in most cases the below-average (and in sometimes dismal) spending on R&D by Muslim countries is a source of grave concern.

Similarly, the UNESCO data on the number of researchers per million of population shows an average of about 600 for the OIC countries, and only Tunisia and Malaysia present solid and increasing numbers, at about 2,000,

Figure 2 – Total R&D Personnel per million of inhabitants*



*SOURCE: UNESCO Institute of Statistics

compared to Brazil (1,000), Spain (4,000), and Israel (9,000).

Finally, and until recently, it has been widely understood, sometimes on the basis of actual data, that science production (research papers published, invention patents registered, citation of works by others around the world, technology exports, etc.) in the Muslim world has been largely trailing behind the rest of the world.

The Task Force deemed it important to investigate this claim and to determine whether any progress has been made in the last ten years or so following efforts made by several OIC countries on this front.

Overall, we find the Muslim world to be lagging behind on most, if not all, indicators of scientific output and productivity; it also significantly underperforms relative to its population size. For instance, the OIC has nearly a quarter of the world's population, but only 2.4% of its research expenditure, 1.6% of its patents, and 6% of its publications.⁷

Table-3 shows the scientific research output of 20 countries of the Muslim world and that of the 5 comparative countries. The data has been obtained using the internationally reputed Thomson Reuters ISI Web of Science database, a rather stringent and high-threshold database of scientific research. This same standard is being applied to all countries (from the OIC as well as for the peer countries).

We present the pooled data for each of two successive decades: 1996-2005 and 2006-2015. A comparison of the results for these two time periods provides a measure of the recent progress made by each country. We list the number of papers produced each year in all science fields, as well as the number of papers divided by the GDP per capita of each country. And as a measure of the quality of the scientific research produced, we compare the citation figures per published paper. In this analysis we have limited the data to science fields (basic and applied); we have excluded all engineering and medical fields, including, for instance, psychiatry, radiology, and surgery.

⁷ Royal Society, 2014, The Atlas of Islamic World and Innovation: Final Report, The Royal Society, London

Table 3 – Scientific Research Output in countries of the Muslim world.⁸

Country	No.s of Papers	Citations	Citations per Paper	GDP per Capita (\$)	Papers / GDP per capita	No.s of Papers	Papers Ratio	Citations	Citations per Paper	GDP per Capita (\$)	Papers / GDP per capita
	1996-2005	1996-2005	1996-2005	2000	1996-2005	2006-2015	2006-15 / 1996-2005	2006-2015	2006-2015	2010	2006-2015
Turkey	32,128	488,841	15.2	4,220	7.6	103,624	3.2	580,000*	5.6	10,136	10.2
Iran	12,429	188,253	15.1	1,537	8.1	94,286	7.6	568,000	6.0	5,675	16.6
Egypt	15,684	180,859	11.5	1,510	10.4	32,251	2.1	185,056	5.7	2,804	11.5
S. Arabia	8,438	77,561	9.2	9,355	0.9	31,425	3.7	182,422	5.8	19,327	1.6
Malaysia	5,928	89,385	15.1	4,005	1.5	34,141	5.8	171,813	5.0	8,754	3.9
Pakistan	3,933	54,854	13.9	514	7.7	25,732	6.5	139,854	5.4	1,023	25.2
Tunisia	4,524	51,945	11.5	2,248	2.0	14,139	3.1	68,023	4.8	4,212	3.4
Morocco	6,867	75,189	10.9	1,276	5.4	8,913	1.3	53,361	6.0	2,823	3.2
Indonesia	2,576	55,410	21.5	790	3.3	6,643	2.6	55,038	8.3	2,947	2.3
Algeria	3,417	39,104	11.4	1,727	2.0	9,901	2.9	48,845	4.9	4,350	2.3
Jordan	2,371	24,430	10.3	1,763	1.3	4,918	2.1	30,898	6.3	4,371	1.1
Senegal	955	18,162	19.0	475	2.0	1,549	1.6	11,824	7.6	999	1.6
Syria	502	8,278	16.5	1,180**	0.4	1,127	2.2	5,879	5.2	2,066**	0.5
Lebanon	1,422	24,832	17.5	5,335	0.3	3,310	2.3	23,485	7.1	8,756	0.4
Iraq	415	3,440	8.3	1,370	0.3	2,422	5.8	6,455	2.7	4,474	0.5
UAE	1,908	24,711	13.0	34,476	0.1	4,689	2.5	33,890	7.2	33,886	0.1
Oman	1,137	13,960	12.3	8,897	0.1	2,286	2.0	12,684	5.5	20,923	0.1
Kuwait	2,676	29,325	11.0	19,787	0.1	3,226	1.2	15,318	4.7	38,585	0.1
Qatar	364	2,883	7.9	29,914	0.0	2,818	7.7	17,155	6.1	71,510	0.0
Bahrain	330	2,498	7.6	13,563	0.0	767	2.3	3,254	4.2	20,546	0.0
Brazil	73,822	1,320,000*	17.9	3,695	20.0	171,879	2.3			10,978	15.7
Spain	156,313			14,788	10.6	261,644	1.7			30,736	8.5
S. Korea	97,321			11,948	8.1	221,073	2.3			22,151	10.0
S. Africa	24,820	513,927	20.7	3,099	8.0	47,765	1.9	461,455	9.7	7,390	6.5
Israel	60,051	1,864,665	31.1	20,902	2.9	67,462	1.1	932,124	13.8	30,551	2.2

*Estimated (proportionately).

**Closest date.

8 Papers and Citations figures from Thomson Reuters ISI Web of Science; GDP per capita figures from: World Bank Database - <http://data.worldbank.org/>

Figure 3 – Resource Productivity of Scientific Research

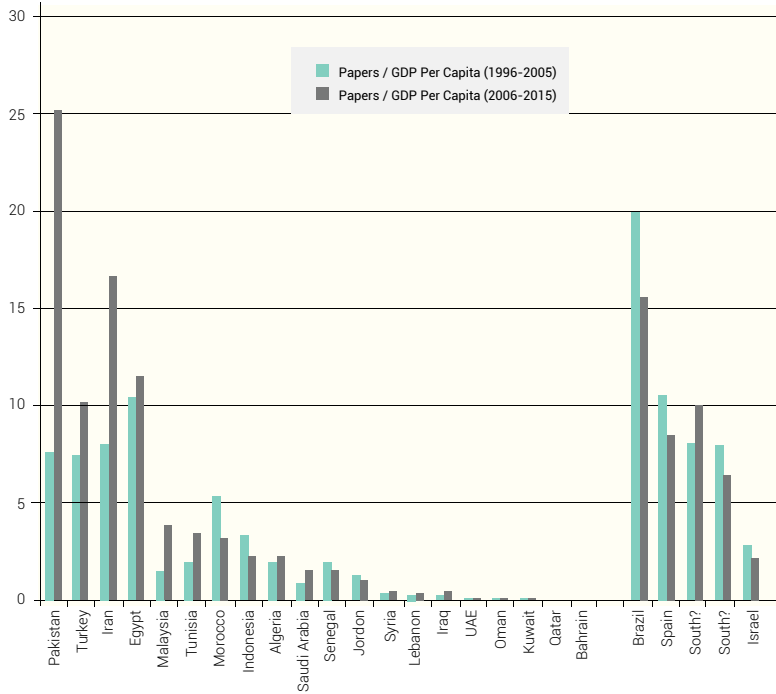
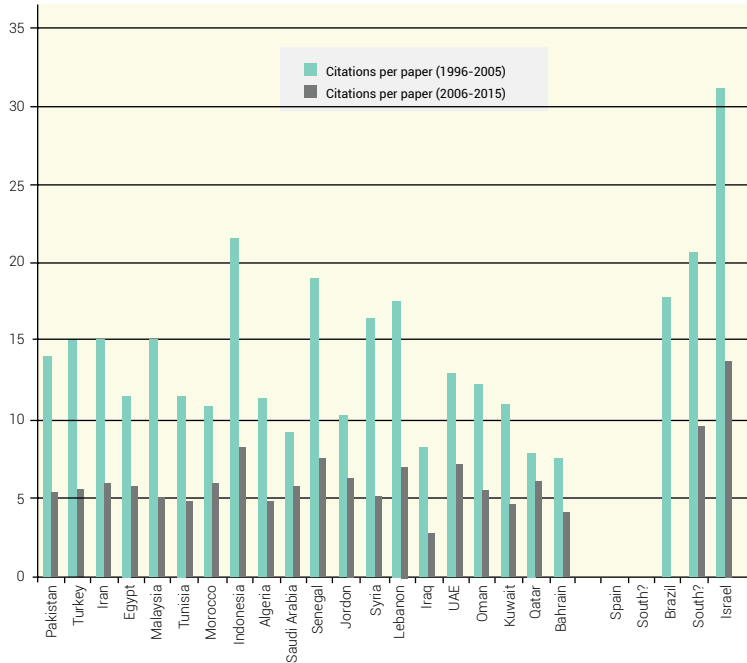


Figure 4 – Citation Impact of Research Publications



A number of interesting conclusions can be drawn from the data in Table 5.

First, all countries have published more scientific papers in the most recent decade (2006-2015) compared to the previous one (1996-2005). While the peer countries have increased their output by a factor between 1.1 (Israel) and 2.3 (Brazil and South Korea), several Muslim countries have achieved striking increases: factors of 7.7 (Qatar), 7.6 (Iran), 6.5 (Pakistan), and 5.8 (Malaysia and Iraq). A few countries have had much more modest increases, but most have improved their output by a factor of between 2 and 3.

Financial resources are, of course, an important determinant in a country's ability to produce scientific research at international standards through factors such as the nation's ability to buy equipment, to competitively attract and retain scientists of high competence, etc.

As we have shown (Table 3), some OIC countries spend a much larger fraction of their GDP on R&D than others. Over the 2000-2012 period, only a few Muslim countries increased their spending on R&D significantly, and only Malaysia recently passed the 1.0% level.

Thus, the research output of countries cannot be compared simply by using the numbers of papers produced; hence, we have "normalized" the numbers by dividing them by the GDP per capita for each country. Except for Israel which scores quite low on this metric, our peer countries achieve a ratio of papers published divided by per capita GDP (in dollars) of between 8 and 20 in the first decade, and 6.5 to 15.7 in the second decade. The best Muslim countries (Turkey, Iran, Egypt, and Pakistan) have similar ratios: between 7.6 and 10.4 in the first decade, and reaching 16.6 for Iran and 25.2 for Pakistan in the second decade.

The number of papers published each year, however, may be a poor measure of scientific quality. We used citation figures, computing citation-per-paper ratios for each country for each of the two decades (with some exceptions).⁹ The peer countries achieve

ratios of 18 to 31 citations per paper in the first decade and 10 to 14 in the second decade (papers published more recently will not have had as much times to be cited often).

It is interesting to note that the 20 Muslim countries have citation-by-paper ratios of about 10 to 20 in the first decade and 5 to 8 in the second decade. These numbers are substantially lower than those of our peer countries, but perhaps other factors are at play (such as the inability for many researchers of the Muslim world to publish in high-quality journals simply due to page charges, which universities pay in the west but those in the Muslim world often cannot afford to, papers from "obscure" universities sometimes are not given the attention they deserve by colleagues in western universities and editorial boards etc.).

The generally low citation figures in the Muslim world may be pointing to a lack of creativity and innovation, but that is only an inference, albeit a plausible one.

In conclusion, as expected, the data shows large variations in the research output and quality from one country to another in the Muslim world. Some countries can clearly be seen to be lagging, and their improvements from the earlier decade to the more recent one have been modest at best. Others have made spectacular improvements, and that must be highlighted and perhaps emulated elsewhere. Overall, the numbers are rather encouraging.

Scientific research output, as expressed by the indicators in the table above, is one typical way of measuring the strength (or weakness) of science in a country, but it is not the only one or the sole yardstick for measuring a country's scientific progress.

Universities, in particular, contribute to research productivity, but they also have a broader mission. A range of input and output variables can be used to better capture and understand the strength and weakness of this important sector. The dearth of data, however, hampers our ability to do solid analyses and comparisons.

⁹ In few cases, citations numbers could not be determined because the online database does not return the query if the count exceeds 10,000 for a given parameter. For example, if one requests data for a country in all science fields over a full decade, the number

of papers is likely to exceed 10,000. This problem can be addressed by compiling data year by year and then adding up, but sometimes even for a given year, the numbers are too large for the database.

At the input level, we are interested not only in the numbers but also the selectivity and quality of student intakes, the number and quality of faculty employed with or without PhD's, the salaries offered to faculty compared to other professions, the language of instruction of the programmes, the types of programmes (sciences, technology, etc.) being offered, and the duration (2 years or 4 years) and intensity (credit hours) of the programmes, among others.

On the output side, we have already discussed university rankings, which are composite, though imperfect, indicators of what universities produce. Other indicators should include the career outcomes of university graduates: admission to prestigious doctoral programs, hiring by world-class companies, institutions of higher learning, and research centers, etc. There is very little data to help us see how the Muslim world fares on a range of these measures, as international agencies, governments, and universities of the Muslim world do a poor job at collecting such data, or at least at making it public.

However, the data presented in the previous pages, somewhat incomplete as it may be, is useful in providing a quick overview of the state of scientific research in the Muslim world, but it does not cover all issues. Indeed, the data does not tell us much about the kind of science that is done in each country and society. In particular, it does not tell us whether scientific research at universities of the Muslim world is innovative and creative or paradigmatically conservative (what Kuhn would call "normal science"). It does not tell us how the research is supported; what collaborations may exist nationally, regionally, or internationally; what role it plays in the university system; etc. In addition, it also does not provide a clear clue of whether the science carried out in most Muslim countries is primarily geared toward local needs and challenges or more generally contributes to the global body of knowledge.

Likewise, it is difficult to know how much inter-disciplinarity/multi-disciplinarity/trans-disciplinarity there is in scientific research at universities of the Muslim world. Indeed, it is not clear from the data presented how much collaboration of any kind takes place in scientific research in the region.

In most of the OIC member countries (10 out of 17 with available data), more than 50% of the Gross Domestic Expenditure on Research and Development (GERD) is spent by the government sector – see Figure 5. This share reaches 100% in Kuwait and over 90% in Indonesia, Tajikistan, and Brunei Darussalam. And higher education is the leading sector in Senegal, Morocco, and Turkey, accounting respectively for 66.7%, 52.4%, and 48.2% of the total GERD; this may be compared with the significant portion of R&D, particularly basic research (55–60%), that is carried out at universities in OECD countries.

Proper and appropriate funding of science remains a serious challenge for the Islamic world, and, to the extent that this results in reducing the attractiveness and performance of science as a profession, it has a direct impact on the subject of this Task Force. It must thus be considered as partly responsible for why science continues to lag behind in the Islamic world.

Even though research centers and laboratories outside of academia play an important role in R&D in the OIC member countries, universities are still critical to the scientific enterprise in two important ways. First, universities host a significant portion of the scientific personnel (PhD holders and graduate students); secondly and more importantly, because universities have the singular distinction of being primarily responsible for producing the scientific manpower that ultimately produces the knowledge that we are interested in.

This Task Force focuses on the state of the universities in the Muslim world, asking the question: to what extent does the role and current operation of universities explain the present state of science in the Muslim world. The Task Force investigates this by focusing on how universities perform in terms of science teaching, dissemination, and service to society, most particularly.

However, before we focus on the state of universities in the Muslim world, let us first review the general state of science education as a critical input into the university system.

Science Education in the Muslim World

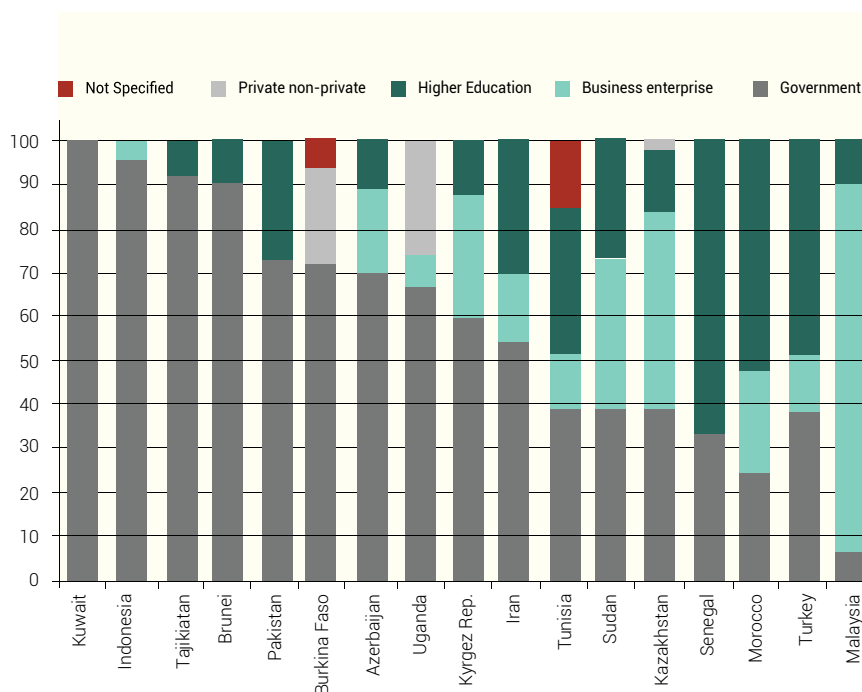
In his essay for the Task Force, Dr. Zou'bi has stated: "Science education is currently viewed as inadequate in the developing and the developed worlds." In his essay, Prof. El-Tayeb addressed science education at universities of the Muslim world, highlighting a number of factors that underlie the general weakness that is observed, including: a decline in the number of students choosing science as fields of specialization, a severe shortage of qualified teaching staff, the failure of the system to turn students into critical thinkers and adopters of the scientific method, the absence of any adaptation or contextualization of the science curriculum (syllabi are essentially the same as those taught in the west), etc. We shall come back to these issues.

Data about science education at the university level is quite scarce. Students graduating from universities of the Muslim world do not take any standardized exit exams, nor any GRE-

type exam for those who enroll in graduate (MSc and PhD) programs. Hence, comparisons are difficult to make among institutions in the region and with the rest of the world. The only data that is available at the university level is tertiary enrollments in science fields and other subjects and some data on enrollments in MSc and PhD programs in a handful of countries of the region.

Before we present those, there is international data on science education at the elementary and secondary level that can give us an idea of the weakness of the teaching of science in the Muslim world before students arrive in college. Indeed, TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) are two standardized tests given internationally every few years, and in which a number of countries from the Muslim world have participated in recent years. TIMSS tests Grade 4 and Grade 8 students in Maths and

Figure 5 – Distribution of GERD by sector of performance (%)¹²



¹² Source: SESRIC, 2008, Research and Development in OIC Countries. Data for the most recent year available..

Table 4 – PISA Results for participating Muslim-majority countries compared with OECD averages, from 2003 to 2012*

Country	Science Score				Math Score			
	2003	2006	2009	2012	2003	2006	2009	2012
Indonesia	395	386	383	382	362	393	371	376
Jordan		433	415			395	387	
Kuwait				409				386
Malaysia				420				421
Qatar		358	379	384		341	368	376
Tunisia	385	393	401	398	360	367	371	388
Turkey	434	416	454	463	423	426	445	448
UAE			466	448			453	434
OECD Average				494				501

Science, and PISA tests 15-year-old students in Math, Reading, and Science.

In 2013, the results of PISA 2012 were released. In the latest round, 500,000 students took part in 65 countries, including several Muslim states and most of the developed world.

The Table 4 shows several important things: 1) only a handful of Muslim countries have been participating in the PISA tests for 15-year-old students, comparing their educational standards at this level with the rest of the world; 2) all the Muslim countries that have participated so far have fared very poorly, scoring well below average, sometimes alarmingly so; 3) reading the results horizontally (for each country over the years), one sees no progress at all.

In the TIMSS tests, given at lower levels and since 1999, 18 Muslim countries have participated in one or more editions, with the most recent tests being in 2011. That year 50 countries participated in total, including 15 states from the Muslim world. Below are the results for the Grade 8 Science tests over the years (with international averages shown in the last row).

The results clearly show that most, if not all, Muslim-majority countries perform well below the world average in science and maths at all pre-university levels (Grades 4 and 8 and Age 15, i.e. Grade 10). Most worryingly, with the exception of Qatar and, to lesser extent, Turkey, the results show no progress over the last 15 years or so at any level (Grades 4, 8,

Table 5 – Grade 8 TIMSS Results for Muslim-majority countries compared with OECD averages (1999 to 2011).¹⁰

Country	1999	2003	2007	2011
Algeria			408	
Bahrain		438	467	452
Egypt		421	408	
Indonesia	435	420	427	406
Iran	448	453	459	474
Jordan	450	475	482	449
Kuwait			418	
Lebanon		393	414	406
Malaysia	492	510	471	426
Morocco	323	396	402	376
Palestinian Natl. Authority		435	404	420
Oman			423	420
Qatar			319	419
Saudi Arabia		398	403	436
Syria			452	426
Tunisia	430	404	445	439
Turkey	433		454	483
UAE			489	465
International Average	488	474	500	500

or 10). In fact Jordan and Malaysia register considerable declines.

* Source: <http://www.oecd.org/pisa/pisaproducts/>

¹⁰ Source: <http://timssandpirls.bc.edu/>

Qualitatively, one can try to put these numbers into context. Writing an Opinion piece in a leading English Newspaper, Dr. Pervez Hoodbhoy, a professor and well-known social critic writes the following about the general level of preparation of children at the end of their school education in Pakistan:

“...Barely three to four students out of 60 could prove the angles of a triangle add up to 180 degrees. None could prove that similar triangles have proportional sides. Quite a few had difficulty with fractions, some did not know how to take the square root of four or nine or unless armed with a calculator, and translating even simple real-life situations (like compound interest) into equations was difficult...”¹¹

The situation may not be very different in other Muslim countries.

As mentioned above, at the university level, one can obtain data for tertiary education enrollment statistics in science fields (from the UNESCO) and science MSc and PhD figures in the Muslim world. Below is the data for 13 countries of the Muslim world, along with data for Brazil, India, and the UK-Ireland (data was often not available for a number of countries).

Table 6 – Tertiary Enrollment in Science Fields (Percentage of students choosing a science major at the university)¹².

Country	2000	2005	2010	2012
Algeria	..	10.4	7.5	..
Bahrain	..	9.0
Bangladesh	..	15.5
Egypt	4.3
Iran	..	13.3	8.1	7.3
Jordan	..	10.6	13.1	9.6
Libya	10.2
Malaysia	..	19.4	11.2	..
Morocco	17.7	16.6	22.2	..
Saudi Arabia	6.6	14.1	15.4	14.5
Tunisia	24.1	..
Turkey	..	7.5	6.5	7.0
UAE	8.0
Brazil	..	8.3	6.3	6.0
India	16.6
United Kingdom	..	14.2	13.3	13.7

In and of themselves, these numbers do not mean much except when one considers the trends within and across countries. In Table 6, we note a large variation in the percentages from one country to another, and often times from one year to another, except for the UK-Ireland, where the figure is steady at about 14 percent. In Egypt it is surprisingly low at 4.3 %; in Iran it seems to have been dropping (from 13.3 % in 2000 to 7.3 % in 2012), likewise in Malaysia (from 19.4 in 2005 to 11.2 % in 2012). In some Muslim countries, the percentages are quite high: around 20 % in Morocco, and around 15 % in Saudi Arabia.

At post-graduate levels, data is available only for MSc and PhD degrees awarded in 2006 at universities in 9 Arab states (see Table 7a).

This limited set of data can still be instructive to some extent; from it we can compute the fractions of MSc and PhD degrees awarded in

¹¹ Hoodbhoy, 2015, <http://www.dawn.com/news/1182200/more-lethal-than-raw>, The Daily Dawn, Karachi, Pakistan.

¹² Source: http://data.uis.unesco.org/MetadataWebApplication/ShowMetadata.aspx?Dataset= EDULIT_DS&ShowOnWeb=true&Lang=en

Table 7a– MSc and PhD degrees awarded in Select Countries in 2006.*

Country	Science and Technology						Total social sciences and humanities plus science and technology						Total Headcount
	MSc.			PhD			MSc.			PhD			
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	
Algeria	8104	72014	15308	4503	3186	7689	13176	12006	25181	7689	4917	12606	37787
Bahrain	30	53	83	1	0	1	273	278	551	1	0	1	552
Egypt	28811	21476	50287	9080	5529	14609	41204	37528	78732	14590	9221	23811	102543
Jordon	434	345	779	30	0	30	881	697	1578	36	0	36	1614
Morocco	4005	2112	6117	3591	2111	6702	8201	4416	12617	8565	4078	10849	23466
Oman	172	91	263	1	0	1	353	212	565	1	0	1	566
Saudi Arabia	2249	1154	3403	239	99	338	5251	3884	9136	1189	1011	2200	11336
Tunisia	3415	3439	6854	-	-	-	7146	11438	18584	--	-	-	
Yemen	341	155	496	-	-	-	1444	546	1990	-	-	-	

Science and Technology (ratio for enrollments in S&T as compared to all fields) for males, females, and total (Table 7b below).

Table 7b – Percentages of MSc and PhD degrees awarded in Science and Technology for males (M %), females (F %), and total.

	MSc			PhD		
	M %	F %	Total %	M %	F %	Total %
Algeria	62	60	61	59	65	61
Bahrain	11	19	15			
Egypt	70	57	64	62	60	61
Jordan	49	50	49	83		83
Morocco	49	48	49	42	52	62
Oman	49	43	47			
Saudi Arabia	43	30	37	20	10	15
Tunisia	48	30	37			
Yemen	24	91	25			

One must also inquire about the reasons that students pursue Masters or Doctorate degrees: do these raise one's social status or do they open doors for more and better jobs? This is an issue worth investigating properly,

*Source: Saleh, 2008 "S&T Indicators in the Arab World", citing data from the UNESCO Science Report 2010.

i.e. through quantitative and qualitative sociological studies. On the surface, it is not clear that graduate degrees, particularly PhD's, improve one's marketability in the Muslim world even though they may open doors to certain leadership positions within academia and government sectors.

Muslim young girls and women in science

We also obtained data on female to male tertiary enrollment from World Development Indicators and ratios of female to male enrollments in science fields from UNESCO data.

Now, even though significant numbers of women study science, there is little data on whether they actually take up science as a profession (though there is some anecdotal indication, e.g. the number of female university professors, that fewer Muslim women end up in scientific careers). There are concerns that women either do not take up scientific careers in large enough numbers because of social and cultural pressures (except for the medical fields) or suffer from high level of unemployment (as reported by Zou'bi and Badran in UNESCO Science Report, 2010) and several are only a bit lower than that of our comparative countries (South Africa at about 40 %, and Spain at about 38 %).

The data below, though incomplete, however, suggests that except for a few countries (such as Pakistan and Bangladesh, and possibly Iran and Jordan) most Muslim countries have

Table 8- Female Tertiary Enrollment fractions (in %).¹³

Country	1980	1995	2005	2012
Algeria			56	60
Azerbaijan		47		51
Bangladesh	15		34	
Bahrain	50	62	78	66
Egypt	32		45	49
Indonesia		39		51
Iran			51	50
Iraq	32		38	
Jordan	47		52	53
Kuwait	63	62		
Lebanon	36		51	52
Libya	26			
Morocco		42	45	
Malaysia	38		55	
Nigeria			42	
Pakistan	28		46	49
Qatar	77	85	78	87
Saudi Arabia	28	46	58	52
Syrian Arab Republic	29	42	47	
Tunisia	30	44	58	61
Turkey	23	38	42	46
United Arab Emirates	67			
Yemen, Rep.			27	
Brazil	48			
South Korea	24	37	39	43
Spain	43	54	55	55
World	46	49	51	52

percentages of female researchers that are comparable to the world average (about 30 %) indicating cultural rather than religious roots of the problem.

In some countries, most notably Pakistan, this has become a matter of public concern. There is currently an ongoing public debate

in the media about lack of participation of women in the medical profession (particularly doctors) and what that means for continued public investment in their scientific education. Anecdotal evidence suggests that less than 50% women who receive a medical degree actually end up practicing in the field.

Table 9 - Percentage of female researchers at universities and government centers.¹⁴

Country	2000	2005	2010-2012
Algeria		34.8	
Bangladesh	14		
Egypt		36.2	41.7
Indonesia		30.6	
Iran		21	27
Iraq		33	34.2
Jordan		22	
Kuwait		35	37.3
Malaysia		35.8	48.8
Morocco	26	26.5	30.2
Oman			24.9
Pakistan	17.9	23.4	27.2
Saudi Arabia	18.1		
Senegal		10	25
Tunisia		44.6	48
Turkey	34.3	36.1	35.8
South Africa	36	39.7	41.7
Spain	34	36.7	38.4

Universities in the Muslim World

We now turn to and focus on universities of the Muslim world.

Universities are the bedrock of a knowledge society. In the developed West, these have evolved over hundreds of years into institutions that specialize in creating and disseminating knowledge. In the Muslim world, and particularly the Arab world, universities are a relatively recent phenomenon. Three quarters of all Arab universities were established in

¹³ Source: <http://data.worldbank.org/indicator/SE.ENR.TERT.FM.ZS/countries>, recalculated as percentages.

¹⁴ Source: UNESCO Institute of Statistics - <http://data.uis.unesco.org/index.aspx?queryid=118&export>

the last 25 years of the 20th century. Fifty-seven percent of them are no more than 15 years old. This observation is important: Higher educational institutions, universities in particular, take a long time to consolidate their institutional structure and to perfect their role in the production and dissemination of knowledge.¹⁵

However, while university reforms will take time, they must be working in the right direction to achieve success. Unfortunately, universities in the Muslim world have, by and large, been too badly funded, managed, or controlled to be able to do their job of fostering an impactful discourse and creating new knowledge. Traditionally, most have been relegated to mere teaching shops, rather than full-fledged intellectual institutions. In short, consistent with the malaise and lack of progress of Muslim societies generally, and probably contributing to it as well, the state of universities in the Muslim world has been far from ideal.

In recent years a number of Muslim countries have undertaken serious attempts at university reforms. In Pakistan, the Higher Education Commission has invested heavily in creating new universities, upgrading existing ones, and funding thousands of PhD scholarships for faculty development. In Qatar, an Education City was created with several foreign universities (e.g. Texas A&M, Carnegie Mellon, and others) in an effort to raise standards, both cooperatively and competitively. In Saudi Arabia, several new universities, such as Princess Noura University and King Abdullah University of Sciences and Technology (KAUST), have been created, in addition to significant investments in the existing ones, as well as serious investments in a foreign scholarship programmes. Malaysian universities have also undergone some upgrades, with the creation of an elite class of research universities. In the UAE, a number of new academic institutions have missions focusing on science, technology, engineering, and mathematics (STEM), such as Masdar Institute of Science and Technology, Khalifa University of Science, Technology, and Research, and The Petroleum Institute, etc.

These initiatives are relatively new, and it is too early to determine whether these have been (or will) create a climate that is conducive to the creation and dissemination of new knowledge and an improved teaching and propagation of science.

University Teaching Issues

The data presented in the previous sections may suggest that there is no intrinsic problem with science as a chosen field of studies by students in the Muslim world. Enrollment figures span a wide range from one country to another, but they are not, on average, too different from what is found in the non-Muslim world, including the developed world.

Likewise, for MSc and PhD degree awards, although our data is limited to the Arab world, we find rather high numbers in the sciences, about 50 % of all degrees awarded at the (post-)graduate level. Here again there are wide variations (Bahrain and Saudi Arabia show very low numbers, and Jordan did not award a single PhD to a female candidate in 2006, in the sciences or in any other field). We stress that we have data only for the year 2006, and thus no solid conclusions could really be drawn. Tables 7a and 7b above must thus be regarded as indicative – at best.

So if enrollments in the sciences are reasonable, and females are not (except in very few cases) disadvantaged at the university level or excluded from science fields, is the problem then one of teaching and curriculum?

There is not enough data to support our investigation at this point, and we thus strongly recommend that surveys be conducted on a number of specific issues. Our conclusions and recommendations (given at the end of this Report) are drawn based on the trends seen in the tables presented in the previous sections, and also partially on the wide-ranging experience of the members of this Task Force.

The quality of science teaching is as critical to creating an effective and productive STEM pipeline and ultimately science careers as any other single factor can be. More often than not, a young person's decision of whether or not to pursue science as a career is made on the basis of one single experience, or one teacher who inspires and motivates and opens one's mind

¹⁵ N. Fergany et al., Arab Human Development Report 2003, p. 56: http://hdr.undp.org/sites/default/files/rbas_ahdr2003_en.pdf

to questions that give birth to a life of curious exploration. In countries where broad-based liberal education is practiced, this happens usually in the introductory science courses in the early years of undergraduate education; in other educational systems, where students choose between the sciences and other disciplines earlier on, this decision is often made as early as high school.

A recent report of the US National Academy of Sciences (NAS) poignantly relates the turning points in a young person's science trajectory:

"If you teach science or engineering or have a strong interest in these disciplines, your undergraduate years were likely a turning point. Perhaps the initial excitement you felt as an adolescent when you observed the luminous clouds of the Orion Nebula through your new telescope grew into a desire for an astronomy career in an undergraduate course when you learned how and why this nebula is a place where stars are born. Or maybe a college field trip to a Paleozoic rock outcrop opened your mind to the immensity and longevity of the forces at work in Earth's formation and spurred you to pursue geosciences. Whatever the inspiration, you persisted through excellent courses and lackluster ones, through stimulating assignments and tedious ones, to complete an undergraduate major in science or engineering and go on to master a discipline.

Based on your own undergraduate experiences, you may assume that most students should be able to learn science the way you learned science, but that is not always the case. For too many students, the undergraduate years are the turnoff point. A single course with poorly designed instruction or curriculum can stop a student who was considering a science or engineering major in her tracks. More than half of the students who start out in science or engineering switch to other majors or do not finish college at all. Maybe they failed a crucial prerequisite course, or found little to engage their interest in their introductory courses, or failed to see the relevance of what they were being taught. For non-majors, an introductory course that confirms their preconception that they are 'bad at science' may be the last science course they ever take."¹⁶

While this is a somewhat simplified depiction of what forces (or withdraws) people from studying and pursuing science, the reality of teaching is often far more complex with many issues involved. Let us explore some issues at the heart of university teaching and curricula.

Curricular and Language Issues

In his essay, Prof. El-Tayeb makes several useful points about the state and quality of teaching at universities of the Muslim world. First, he has noted that science curricula are essentially imported "as is" from the West. He reviewed the curriculum of biology at universities that he is familiar with in the region, compared it with what is given at Oxford University, and found little difference, if any. The same is true, he noted, in geology and earth sciences. It is not quite clear whether this is also the case more widely and generally in the rest of the Muslim world and, more importantly, it is not clear to what extent curricula in the sciences should be affected by the local culture, but this is an issue that should be subjected to more research.

Indeed, Prof. El-Tayeb brings up the topic of Darwin's theory of evolution, and while he notes that it is rather widely taught at universities of the Muslim world, at least in majors that need that topic to be covered, he bemoans the fact that it is taught "in a fragmented way at the undergraduate level" and that "the teachings always conform to tradition, not to science as taught in the west"; he adds that the damage is often done in the "closing remarks from the instructor".

Prof. El-Tayeb also mentions the issue of language in the teaching of science at universities of the Muslim world. He notes that except in very few cases, English or French are the default languages used for science courses in most universities of the Muslim world. The pros and cons of the adoption of the local language in lieu of a foreign language when teaching science subjects have not been rigorously investigated, particularly in the Muslim world, though some evidence exists of the effect of teaching science and mathematics using a second language in early-school education. Here, evidence seems to suggest that teaching science and mathematics in

¹⁶ NAS, *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering*, National Academy of Sciences, United States, 2014.

local languages enables children to develop scientific ideas faster, and a lack of mastery of the second language serves as a barrier to learning science.¹⁷ Indeed, some countries, such as Malaysia, have lately reverted back from teaching science and mathematics in English to their native language after having experienced declining test scores, though many of these decisions also have political motives.¹⁸

It is important that the language issue be explored at the university level, and it is essential to distinguish the pedagogical aspects from the socio-political reasons that may influence the question of the language used in universities of the Muslim world. Moreover, one may not have to choose between the local language and the foreign one in binary fashion; perhaps each can have some place and be used appropriately in various contexts (textbooks, labs, advising, extra-curricular activities, etc.). There is some experience in the teaching of science in Arabic (for instance: medicine, in Syria, and other sciences in some institutions in Algeria and elsewhere), and reports suggest that this does not hinder the ability of the graduates (physicians or BSc/MSc holders), to perform well subsequently on tasks (such as passing a professional qualification) requiring English.¹⁹

Here the experience of other non-western higher education systems (e.g. Brazil, South Korea, and others) may also be beneficial to draw upon.

This is a long-standing debate, but the logical approach seems to be to balance native language instruction with an engagement with English to ease access to the international scholarship, which today is largely in English. This has led one proponent of the Arabisation of Science movement to argue that "English proficiency is necessary to make important strides in the Arabisation [localization] of science"²⁰, meaning that it may be best if students develop competency in multiple (at

least two) languages.

Pedagogy: Inquiry-based science education

Beyond what is taught and in what language it is taught, the question of how science and mathematics are being taught is of critical importance too. Every STEM teacher must ask the following questions as he/she prepares to stand in front of the young and the curious to teach:

- Is your style of teaching drawing students to science and technology—or driving them away?
- Are you teaching in a way that motivates, engages, and supports the learning of all your students, including those with backgrounds or approaches to learning that differ from your own?
- Are your courses and your department's programs serving as gateways to learning science or engineering, or gatekeepers?

Many of these questions address how science education is imparted at universities and hence fall within the realm of pedagogy.

Prof. El-Tayeb brings up the pedagogical competency (or lack thereof) of the professors who teach various science subjects. Indeed, one must recall that university faculty are hired with a PhD in their fields; sometimes they will have had some experience as teaching assistants during their doctoral studies and sometimes not, but rarely – if ever – will they have received any pedagogical training. They end up learning the teaching trade on their own and in an improvised manner. Thus, pedagogical (re) training of science professors is a must. It is here that the universities in the Muslim world probably lag the most behind those in the more developed world, where many new initiatives and innovations on how STEM must be taught are currently underway. Outstanding examples can be found as the winners of the IBI and SPORE Prizes, competitions designed to inspire science educators to innovate with new pedagogical approaches. These are available on the open-access 'Science in Classroom' portal hosted and published by Science.²¹

Prof. Alberts, the former President of the US National Academy of Sciences and Editor-in-Chief of the journal *Science*, and an expert advisor to the Task Force, emphasizes the critical importance of improving the methods

¹⁷ Nagao M., Rogan J., Magno, M., 2007, *Mathematics and Science Education in Developing Countries: Issues, Experiences, and Cooperation Prospects*, UP Press

¹⁸ http://www.nytimes.com/2009/07/09/world/asia/09iht-malay.html?_r=0

¹⁹ <http://www.scidev.net/global/communication/opinion/language-science-education.html>

²⁰ Ibid

²¹ <http://portal.scienceintheclassroom.org>

of teaching science at the university level. He stresses two important ideas: a) new active-learning approaches (new “instructional technologies”) have been developed and shown through research to be highly effective; these evidence-based approaches should be adopted widely, utilized extensively, and improved upon; b) heavy syllabi are counter-productive, less “coverage” is strongly recommended, particularly in first-year courses and in pre-university schools.

Indeed, the idea that evidence-based approaches should be the way forward for science education at the university level seems to have caught on in the developed world. The US President’s Council of Advisors on Science and Technology notes:



A large and growing body of research indicates that STEM education can be substantially improved through a diversification of teaching methods. These data show that evidence-based teaching methods are more effective in reaching all students—especially the ‘underrepresented majority’—the women and members of minority groups who now constitute approximately 70% of college students.”²²



And both Prof. Lee Cheong and Prof. Zou’bi have stressed the need to adopt IBSE (inquiry-based science education) as a general approach to the learning of science, at the university level as well as at the elementary and secondary school level. They have presented some examples of the adoption and implementation of IBSE programs, for instance ‘La Main à la Pâte’²³ in France and other similar programs in the developed world. And they have recommended the adoption of IBSE with a “local flavor”, for example Prof. Djebbar’s program titled ‘Découvertes en Pays d’Islam’²⁴ which helps teach science ideas by relating to great examples and stories from the golden

age of Islam, the ‘1001 Inventions’ traveling exhibition, and other such programmes.

Finally, the dearth of internship programmes for science majors has been noted. In connection to the above-described need for the adoption of IBSE, a similar adoption of service learning and project-based learning is very much needed for a full appreciation and mastery of both the scientific method and various applications in the local context and environment. Internships can be the perfect way of implementing and achieving these two goals. They are difficult to organize and run but, if done right, their “return on investment” can be very high. Indeed, we must stress the need and importance of internship assessments, for in many cases the internship “programme” can be quite appealing by its title, but in reality the programme is often clerical and without much learning value.

Balance between basic and applied sciences

Related to the above, a balance must be achieved between the basic and applied science programmes. There is often a disconnect between the two at the universities of the Muslim world, and perhaps more widely across the developing world. Students are forced to choose either pure science and get little exposure to design and engineering and applied subjects, or they choose applied fields and get “shielded” from their theoretical contexts. This “separation” sometimes occurs from the very first year of their science or engineering studies.

Faculty members themselves tend to split sharply between the two areas. This is not a recipe for progress and success. Scientists and engineers can only be creative and innovative if they have as broad a base of knowledge as possible and a flexible mind that can relate to the theory and fundamentals of a given problem, see its application or context clearly, and make good use of this information. More balanced curriculum, thus, need to be constructed in both the sciences and engineering.

Prof. Mimouni remarks that the situation is quite diverse in the Muslim world: some countries (e.g. the Gulf) have very few or weak basic-science programmes, others (e.g. Algeria) may have stronger basic-sciences programmes. However, he sees a more worrisome gap

²² PCAST, Engage to Excel, President’s Council of Advisors on Science and Technology, United States, 2012

²³ See: www.fondation-lamap.org/

²⁴ See: www.fondation-lamap.org/fr/decouvertes-islam

between the full-fledged engineering (4-5 years) programmes and the shorter (2-3 years) technician training programmes. Indeed, the latter are often found to provide inadequate preparations for the technical jobs the students are presumably being prepared for.

Curricula should also be more "rounded", i.e. they contain enough general education (humanities, social science, languages, and communications, etc.) to ensure that science graduates in the Muslim world are not exclusively technically competent at the expense of broader knowledge. It is widely agreed that broader knowledge gives scientists and engineers new perspectives, thus more creativity in solving problems of various kinds, and helps them conduct research and other works with colleagues of different backgrounds and communicate better with superiors, officials, and the public at large. Prof. Razak insists that curricula for basic-sciences programs should include courses in the humanities, particularly the related topics of history and philosophy of science.

More generally, both Prof. Razak and Prof. Mimouni decry the dearth of multi-disciplinarity and trans-disciplinarity in the education and mindsets of scientists, even though the Islamic culture of learning strongly promotes a more holistic approach.

Liberal education and soft skills

The 'liberal education' philosophy that is characteristic of American universities is indeed based on such a broad general education, which includes language, humanities, social sciences, communication, etc.; the proportion devoted to such courses varies from one university and accreditation system to another, but it generally amounts to about one third of the entire education of students. Liberal education is designed to inculcate several important qualities and capabilities within young people. For instance, a liberally educated person is described as someone who :²⁵

- can think and write clearly, effectively, and critically, and who can communicate with precision, cogency, and force;

- has a critical appreciation of the ways in which we gain knowledge and understanding of the universe, of society, and of ourselves;

- has a broad knowledge of other cultures and other times, and is able to make decisions based on reference to the wider world and to the historical forces that have shaped it;

- has some understanding of and experience in thinking systematically about moral and ethical problems; and

- has achieved depth in some field of knowledge.

Thus a liberal education focuses on teaching young people how to think, rather than what to think, and how to learn, rather than what to learn.

There are very few universities in the Muslim world that consciously seek to inculcate these qualities through a 'liberal' educational experience. Not only are most scientific and technological programmes very narrowly disciplinary, but the choice of going into either sciences and engineering or other kinds of knowledge is made at a very early stage. For instance, at the American University of Sharjah, a student who majors in Chemistry must take: 5 courses in Language and Verbal-Written Communication; 5 courses in Humanities and Social Sciences; 1 course in Arab-Islamic Heritage; and 5 courses of Free Electives to be taken in any topics and fields. These (courses outside of the major) thus represent 37.5 % of the student's total credits.

This is not typical in science majors across the Islamic world, although this approach is now being adopted by a number of institutions here and there. For example, the Bangladesh Rural Advancement Committee (BRAC) has recently established BRAC University that aims to reflect the needs and aspirations of Bangladeshi society by producing graduates who will work to alleviate poverty and to overcome the country's severe problems in the areas of health care, education, and employment; and this university offers a liberal education curriculum.²⁶

In Pakistan, the Aga Khan University and Habib University – two private sector universities – are attempting to do the same. Aga Khan University has sought to initiate a liberal arts programme aimed at helping

²⁵ David E. Bloom and Henry Rosovsky, *Why developing countries should not neglect liberal education*, *Liberal Education*, Vol. 89, No. 1, pp. 16-23, Winter 2003

²⁶ Ibid.

its medical graduates become more holistic healers. Habib offers a strong 'liberal arts core' for all its undergraduate students including those in the sciences and engineering.

Prof. Zou'bi, in his submission to the Task Force, also noted the dearth of Science and Technology Studies (STS) programmes in the Muslim world. In 2004, there was only one such program in the entire Islamic world (at University of Malaya), which meant that universities were not producing policymakers and experts who could critically evaluate the state of science and science education in the Islamic world. The whole disciplines of sociological and economic studies of science, which have contributed to understanding and improving the conduct of science in the West, are relatively unknown in the Islamic world. There are, of course, issues of employability for every specialty, but neither extreme dearth nor overproduction of graduates in any field bids well for the society at large.

Also missing is the "binocular" of history and philosophy through which a full understanding of science, its evolution and its goals, can be achieved. The Task Force has stressed the importance of rounding the scientific education of students with these topics and others, decrying in passing the gradual disappearance of many departments of philosophy from universities of the Muslim world.

Addressing the religion-science interface

Finally, the Task Force discussed whether any religious "red lines" might be affecting science at the universities of the Muslim world in all aspects of the institutions' tasks, i.e. teaching, research, dissemination, and public outreach.

As noted above, the theory of evolution, particularly human evolution, remains a contentious issue and is often resisted; in some cases, it is totally absent from an entire university's slate of courses, even for science students. How a student can graduate with a degree in the sciences and never have been presented with a theory that constitutes the backbone to most of biology, paleontology, and other fields, is quite a perplexing situation, but it is indeed the case for thousands – perhaps millions – of science students in the Muslim world.

More generally, the question of the extent to which "religion" (Islamic beliefs) may play a role in the science classroom has been addressed by the Task Force, particularly by Prof. Mimouni in his essay, quite at length. When students object to, or at least inquire about, a scientific statement (theory, fact, or claim) on the basis of their religious education, what should be done? Prof. Mimouni concludes that NOMA (Stephen J. Gould's "Non-Overlapping MAgisteria"), while not an ideal panacea, should be adopted in the classroom at least to prevent various kinds of slippages (teachers disseminating their own religious beliefs while attempting to answer a student's question that brings up religion with respect to a scientific matter). Prof. Mimouni also recommends that bridge courses between Science and Islam be developed and offered (perhaps in an inter-disciplinary format) to address all the questions that students may have on issues that come up at the interface of the two.

Other fields, such as Anthropology and Bio-engineering (e.g. studies of stem cells and such) may also be subjected to religious constraints. In some cases, however, ethical considerations may very legitimately restrain experiments, though perhaps not theoretical investigations.

Prof. Reiss has suggested that perhaps an emphasis on "understanding" rather than "convincing" should be adopted as the objective in the science classroom. Students will later draw their own conclusions on how to relate the science to their own worldviews.

Furthermore, Prof. Razak has stressed that university curricula should be 'aligned' with Islamic values. On the general education and ethics that students must receive at universities of the Muslim world, he points out that the International Association of Universities has adopted a 'Guideline of Ethics in Higher Education', and it is highly recommended that they be consulted, adopted, and implemented.

Prof. Mimouni also bemoans the fact that ethical principles that are dear to Islam, most notably intellectual honesty, do not seem to always spring to action in academia. In particular, the widespread practice of plagiarism, and the fact that it is treated mostly with a blind eye by the educational establishment in general, is a great ethical failure. This is in total contradiction to the rules of behavior set by Islam, particularly

the obligation of fairness and respect toward others' property (material or intellectual), etc.

Prof. Najam, in his submission to the Task Force, makes an important point. While the flow of political interest and even funding in recent years have apparently revived the fortunes of higher education sector in many Muslim countries, quality is not always improved. He notes:

“**The policies seem to be sensible ones: invest more money into universities, especially in the sciences; improve salaries of researchers and professors; send scholars abroad for advanced training; establish rewards for teaching and research; build norms for better university management; improve infrastructure; provide support to students; develop metrics and rankings to reward good performance. Yet, there is disenchantment with the results. The number of universities has rocketed, but their quality has slid. There are more publications, but also more plagiarism. All universities have better infrastructure, very few – if any – have better teaching. Far more people roam about with PhDs, but the scholarly discourse seems stagnant or falling. Trapped in a fetish of measuring quantity, we see quality slipping all around us. Rankings come up with weird results, junk science is put on a pedestal, ghost journals abound.**

The implication being that a policy agenda – no matter how well-meaning or generous – that ignores the readiness of a society to accept and embrace it, and invests no attention in creating that readiness, is doomed to stumble. Thus policymakers (and the universities) must play a role in shaping readiness and expectations of the broader society for the reforms to bear fruits.

Outreach Role of Universities

The Task Force members were in agreement that universities of the Muslim world do much too little in terms of outreach. In the absence

of involvement of professors and scholars in educating the general public, society is left with unqualified people speaking or writing to the public on subjects that they have no expertise on but which academics and other experts should speak on or at least correct any misinformation that often leads to confusions and even panics (as in the case of earthquakes, eclipses, epidemics, etc.). Islam, through numerous well-known injunctions and teachings, makes it an obligation on scholars to spread knowledge widely (an act commonly referred to as “zakat”, or alms, of one's knowledge).

However, as Prof. Razak notes, outreach is generally seen as a marginal activity at universities of the Muslim world because of the poor recognition/rewards accorded to it as compared to academic publications (not always in world-class journals”). We may thus recommend that ‘outreach’ be considered as an important form of ‘service’ (along with ‘teaching’ and ‘research’) in the duties of faculty members. Perhaps awards for most significant outreach activity could be instituted to encourage professors to partake more vigorously in such important endeavor.

Prof. Najam makes an equally compelling case for Universities’ role within the broader society. He presents five propositions that he claims collectively suggest that the scientific barrenness of the Muslim World is explained not only by what is happening in our Universities, but by what is not happening in our society. The obvious implication, then, being that attention needs to be invested not only towards our universities but equally on Muslim society itself.

He concludes by stating that it is indeed the job of the university to create a society around us and, in the process, be created by it.

“**It is a fundamental purpose of the University is to shape, and constantly reshape, society. Just as society is reflected in the University, the University has the ability to shape society. It does this through the knowledge it produces, but much more by the habits of the mind that it instills in its students.**

Conclusions

There is no doubt that science has become central to all societies of the world today in terms of economic progress, geostrategic status, human development, and other aspect of human condition and endeavor. The Muslim world must place knowledge/science in the high abode that Islam accorded it and put it at the center of its strategic development plans.

Academies, ministries, opinion leaders, and media platforms must stress that science is not a western product, and that it has no intrinsic cultural or ideological identity. Examples can be presented from the past and the present of successful scientists from various cultures and belief systems.

For science to flourish in the Muslim world today and in the future, we must create conditions for scientists to achieve a higher degree of influence in their nations and the world. Likewise, champions and patrons of science should be widely promoted and advertised throughout society, e.g. by publicizing waqf initiatives for scientific projects.

Universities have a central role to play in this regard. In their general outlook and policies, they must stress quality over quantity:

a) enrolment numbers are only quantitative measurements; at best they can allow institutions to manage various programmes better by allocating resources (human and financial); they should never be used as a measure of "achievement";

b) university rankings and other quantitative assessment tools (e.g. numbers of published papers, citations, etc.) may be used carefully and positively, i.e. to ensure improvements both qualitatively and quantitatively in various metrics (success of graduates and alumni, valid production of knowledge, etc.) and never become objectives in themselves which often leads to new academic ills (plagiarism, ghost journals, dubious research, artificial citations, etc.).

Furthermore, in aiming to raise the quality of their "products", universities must strive to continuously improve the teaching that is delivered at the undergraduate level; for instance, senior (experienced) professors should be strongly encouraged to teach at the

lowest levels of the curriculum, particularly the foundational (first-year) courses, bringing to bear their many years of learning and experience.

The Task Force has also stressed the importance of adopting wide-base, general-education curricula for science majors: roughly one third of a science student's education should be around languages, humanities, social sciences, and communications, if we want to avoid the "two-culture" dichotomy that graduates of the Muslim world have widely been found to suffer from and the lack of flexible, wide-scope, interdisciplinary, and creative approach and mindset that innovations now require.

Finally, the Task Force has stressed the importance of outreach by scientists and university professors both as a way of showing the relevance of science and its benefit to society and pulling the general scientific culture of society upward and forward. Outreach needs to become part and parcel of university professors' duties and activities, and academic institutions need to acknowledge those activities and promote them. Indeed, 'outreach' and 'science communication' should be considered as important forms of 'service' (along with 'teaching' and 'research') in the duties of faculty members. Perhaps awards should be instituted for most significant outreach activities with an aim to encourage professors to contribute more substantially.

Recommendations

The Task Force has collected and produced as much data of relevance to the topic of science in universities of the Muslim world as possible with available resources. Still, as we have noted, important data is non-existent on a number of indicators and factors, most particularly: profiles of science-subject graduates and their career paths; profiles of professors teaching basic science; curricula (textbooks and course contents), pedagogy (lectures, small/big classes, discussion sessions, experimental courses and their contents), language of instruction, and everything of relation to the teaching and practice of science at universities (small, large, public, private, etc.).

The Task Force thus calls upon official (preferably trans-national) bodies, such as the Islamic World Academy of Sciences (IAS) or

the Islamic Scientific, Educational and Cultural Organization (ISESCO), to periodically undertake the collection of such data, as extensively as possible. This data should be collected and made publicly available in a way that makes both cross-sectional and longitudinal analyses possible. This will allow a finer analysis of the above issues and sharper recommendations at various levels.

The data that we produced and/or analyzed shows that in some areas, the Muslim world is doing reasonably well (e.g. on the fraction of students enrolled in science fields, the fraction of female students, etc.) or has at least made significant improvements in the last ten years or so, such as on the production of scientific papers.

However, the "state of science" as a whole in the Muslim world remains below satisfactory levels; in particular the levels of spending on

scientific research are still much too low in most OIC countries; the percentage of people doing research and development remains low; few universities can be found in the top few hundreds of world rankings; etc.

The Task Force has concluded that universities of the Muslim world have not made nearly as much progress in terms of quality of instruction (and other tasks) as quantitative increases have occurred.

The Task Force makes 10 recommendations divided into 3 sections/areas, according to the major audiences being addressed:

A1-A4 for academic institutions (universities, schools, etc.);

B1-B3 for national policymaking and implementation institutions (e.g. Ministries)

C1-C3 for key stakeholders (Academies of science, industry, civil society, etc.);

A) Recommendations for Academic Institutions:

A1) Rethink science curricula at universities (i.e. 'what should be taught?')

- **Adopt a broad-based, general-education curriculum** for students majoring in all science and engineering disciplines. Complement students' technical education by adding humanities topics of direct relevance to science (Philosophy of Science, History of Science, Ethics of Scientific Research, etc.), basic social sciences, and communication skills (languages and verbal and written communication).

- **Re-orient universities towards their student-centric missions:** create endowment funds for students who might be prevented from pursuing science majors due to lack of financial means; improve the capacity of graduate programs to attract talented students by addressing issues such as attrition rates, time to degree, funding, and alignment with student career opportunities and national interests; etc.

- **Encourage multi-disciplinarity in training as well as in the choice of courses for science majors**, such as connecting science programs with both engineering and social science programs.

- **Implement internships in science fields for students at the end of their junior year**, allowing this experience to be incorporated in final (senior-year) projects (link with industries and local community companies, research institutions, etc.).

- **Engage undergraduates in faculty research to give them early exposure** to how scientists think, formulate problems, and create and implement strategies to solve them.

A2) Adopt effective teaching pedagogies for science (i.e. 'how should it be taught?')

- **Adopt IBSE/Active-Learning teaching methods**, e.g. "clickers", group learning setups, and other approaches that develop critical thinking, e.g. analyzing science papers from the literature, newspaper articles about scientific topics, etc.

- **Adopt and popularize the notion of Discipline-Based Education Research (DBER)** in creating, experimenting with, and delivering science instruction in the classroom .

- **Re-train the faculty on modern and new pedagogical approaches** that develop in students creative thinking, critical inquiry, and rejection of "the argument from authority".

- **Enable and encourage faculty members to use modern technological tools**, such as new media approaches, learning management systems, simulations, etc. for a better and more enriching learning experience and to make science instruction fun, where possible.

- **Develop contextualised curricula** by enabling and encouraging faculty members to develop new courses, write textbooks and develop curricula that take into account local conditions and contexts.

A3) Transform universities into meritocracies (i.e. 'hire, incentivize, and empower')

- **Attract quality faculty – particularly expats – and create productive networks around them.** Universities (and departments), it is said, are built around individuals not physical assets or buildings. Muslim expats living and working in the West could be a starting point for such an exercise. Several high-income Muslim countries such as those in Persian Gulf and South East Asia should be able to do even better.

- **Provide intellectual and administrative autonomy, freedom of thought and expression, and the ability to pursue one's interests.** People in academia self-select to a life of relative autonomy and freedom, and this forms a very critical part of their intrinsic motivation system.

- **Support faculty research through ‘early career grants’ and ‘merit-based competitive research grants.’** This could be done through endowment funds or partnerships with industry actors. Even if the amounts are small, they provide an impetus, the first exposure, and a foothold on which to build one’s independent research career and serve as starting points for young faculty to go out and raise more money.

- **Support Pedagogical Innovation through an institutional small grants programme focused on curricular and pedagogical innovation.** These grants could be used to fund faculty time to develop such approaches, attend training programmes, or buy equipment needed to implement new approaches.

- **Institute a system of rewards, recognition, and promotion that measures faculty performance in teaching, research, and outreach.** Rewarding and recognizing quality teaching – ideally through the promotion system – is critical to ensuring that faculty will spend time and effort to be better at it. Recognition (through teaching awards, for instance) is one important way to encourage faculty to focus serious attention and time on this essential university mission.

A4) Revive the universities’ social contract with society (i.e. ‘relevance and service’)

- **Connect universities to schools** – primary, secondary, and high schools – to ensure conceptual and curricular continuity.

- **Create public outreach and science engagement programmes** that enhance the citizen’s engagement with and appreciation of science and the scientific method.

- **Ensure that STEM curricula make reference to national and social agendas**, e.g. health and medical programs (obesity and diabetes epidemics, cancer prevention and detection, etc.).

The Task Force invites interested universities from around the Muslim world to engage, substantively, in a conversation around the above set of recommendations and seeks nominations by a ‘coalition of the willing’ to endorse and adopt these recommendations and become partners in an ‘implementation programme’ presented below.

B) Recommendations For national policymaking and implementation institutions (such as Ministries):

B1) Provide greater autonomy and flexibility to universities for:

- **Designing innovative curricula and research programs**, and supporting a pedagogical innovation fund

- **Relaxing often cumbersome and restraining regulations** so as to enable universities to transform themselves into meritocracies that reward performance. Define career paths that young scientists find meaningful, attractive, and challenging.

B2) Support a university culture of accountability, evaluation, and best practices:

- **Produce extensive data** (for as many universities as possible, cross-sectional and longitudinal) on science graduates, curricula, pedagogy, languages of instruction, as well as employment rates and work profiles of science teachers/faculty, science graduates, etc.

- **Improve the quality of higher education regulation and certification, and adopt a zero tolerance policy towards academic fraud.** Consider effective mechanisms of signaling quality, where market information fails to do, such as national and regional rankings of institutions with similar missions, setting up information clearinghouses, etc.

- **Engage with academies of sciences, where possible, to create oversight panels** that ensure that quality science education is delivered.

B3) Address national policy issues in a timely and effective manner.

- **Ensure sustained funding for higher education institutions** that approach international norms (about 20-30 % of all government spending on education). The higher education spending should also include funds for development and research. The funding policy may encourage, through inducement and incentives, universities to gradually raise endowments to support faculty research and student scholarships.

- **Address the issue of the language of instruction by undertaking rigorous research on the question and examining the pros and cons of various propositions (bi-lingual, etc.).** In parallel, create national science translation projects to ensure the availability of up-to-date scientific content in national languages, including articles, special issues, and books on science education

- **Adopt and implement a full-system approach to enhancing STEM education within the society**, by ensuring that what is taught within schools is well-integrated with university curricula. Develop consistency in both what is taught (syllabus) and how it is taught (pedagogy) throughout the educational continuum. Conduct re-training workshops for science teachers to bring them to date with new tools and knowledge.

C) Recommendations for Key Stakeholders (science academies, industry, civil society, etc.)

C1) To enable important stakeholders within the society to constructively engage with universities:

- **Create greater linkages between academies of science and university programs** to ensure currency in terms of content and pedagogical approaches.

- **Establish multi-stakeholder advisory boards and curricular committees for each science program**, bringing together educators, policymakers (administrators, officials), business and industry leaders, and other civil society actors.

- **Create Science-to-Action councils** at every university to engage scientists and science students in tackling local problems and challenges.

C2) To enhance the national profile of sciences and STEM careers:

- **Encourage students to take part in international competitions and scholarships**, such as Intel Science and Engineering Fair (ISEF), the International Science Olympiads, the Meetings of Nobel Laureates, etc.

- **Engage the media in its various forms** in promoting scientific culture, values, and role models within the society.

- **Popularize science and provide routes for the successful commercialization of its relevant discoveries.**

C3) Enhance the representation within STEM of minorities:

- **Involve youngsters in the dynamics of science**, e.g. by creating and supporting national and regional young academies of science along the lines of Pakistan's National Academy of Young Scientists (NAYS), the Arab World Academy of Young Scientists (ArabWAYS), etc.

- **Stress gender neutrality of science** by highlighting, in equal measure, bright examples of scientific success among young women (and men). Create special programmes to attract young women to STEM education and STEM careers, where such a deficit exists.

Epilogue: Moving forward

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Muslim World Science

Initiative is seeking to create an alternate platform for catalyzing a frank and honest dialogue on issues at the intersection of science, society and Islam. Universities and whether they perform (or not) are critical to the creation of a scientific culture and revival of the fortunes of the Muslim World. This Task Force has done a commendable job of laying the groundwork for that important conversation. I am sure where we decide to go from here will be equally groundbreaking...

”



Athar Osama

Project Director, The Task Forces Project
Founder, Muslim World Science Initiative

Next steps: A proposal for a Network of Excellence of Universities for Science (NEXUS) in the Muslim World

The Task Force members strongly believe that the most appropriate venue for action on these recommendations is the university itself. The most essential ingredient in creating excellence in science and science teaching at a university is a realization, within a university's highest leadership and its faculty, of the need to give up the old and dated ways, renew the purpose, and re-write the genetic code of their university.

This will not happen overnight, but it needs to take place slowly but surely through a series of interconnected and deliberate steps: to hire, train, incentivize, and empower faculty to teach better, to carry out relevant research, and to be of service to the community and the society at large.

The Task Force members are also convinced that a bottom up – rather than top-down – movement of reform that creates a few examples of excellence among universities in the Muslim world could have a powerful demonstrative effect on other universities who may be inspired to replicate such success.

An implementation program to create a 'NEXUS' of such self-selected institutions is being created as a primary vehicle to take the ideas of this Task Force forward. Once created the Task Force, and a Muslim World Science Initiative's Secretariat, shall provide advice and support to universities that endorse the recommendations of the Task Force and pledge to make progress in gradually implementing them.

Implementation Program for NEXUS Institutions

A detailed programme for NEXUS Institutions shall be constituted to implement, in a phased manner, but not limited to, the following set of recommendations:

- **Establish joint advisory boards and committees for each science program**, to include: educators, policymakers (administrators, officials), business and industry leaders, and civil society.
- **Adopt a broad-based, general-education curriculum** for students majoring in all science and engineering disciplines. Complement students' technical education by adding humanities topics of direct relevance to science (Philosophy of Science, History of Science, Ethics of Scientific Research, etc.), basic social sciences, and communication skills (languages and verbal and written communication).
- **Adopt IBSE/Active-Learning teaching methods**, e.g. "clickers", group learning setups, and other approaches that develop critical thinking.
- **Acquire online-learning tools/platforms** such as smartboard for a fuller learning environment and experience, thereby also preparing students for lifelong learning.
- **Re-train the faculty on modern and new pedagogical approaches** that develop in students creative thinking, critical inquiry, and rejection of "the argument from authority".
- **Implement internships in science fields for students at the end of their junior year**, for that experience to be incorporated in final (senior-year) projects (link with industries and local community companies, research institutions, etc.).
- **Develop "bridge courses", seminars, etc., to address religious questions** that come up in science courses.
- **Set up a system of tutoring, whereby science students can get help from faculty members and/or senior students (peer tutoring)** to get personalized attention for full-fledged academic development.
- **Encourage the involvement of undergraduate students in faculty research.**
- **Encourage multi-disciplinary studies across the university: connect science programs with both engineering and social science programs, etc.**

Science Education in the Islamic World: A Snapshot of the Multi-layered Role of Academies of Sciences and the Academe

“How can we ask or expect young children who have, for example, just enjoyed a non-conformist inquiry-based science education (IBSE) class to switch back to a traditional mode of learning in a subsequent history or language lesson, for example. Shouldn't we start thinking of turning most of our education into Inquiry-based Education (IBE)?”



Moneef R. Zou'bi
Director General of the Islamic World
Academy of Sciences, Jordan

Science Education in the Islamic World: A Snapshot of the Multilayered Role of Academies of Sciences and the Academe

By: Moneef R. Zou'bi

Director General, Islamic World Academy of Sciences (IAS)
Amman, Jordan

Science Education: Why?

Science education²⁷ is currently viewed as inadequate in the developing and developed worlds. This was highlighted at the recent InterAcademy Panel (IAP) Science Education Programme (SEP) Biennial Conference, held in Beijing, China, in October 2014. In the Beijing Declaration issued at the conclusion of the conference, IAP member academies, governments, the private sector and UNESCO were urged to strengthen science education around the world - with a focus on the proven methods of inquiry-based science education (IBSE). The participants agreed that many of the challenges facing humanity today including sustainable development, climate change, population growth, health, food insecurity, energy security, water management, etc. could only be addressed by an educated population and decision-makers who are science-literate.

The inadequacy of science education renders imperative the need to promote it at all levels throughout the world, particularly in developing countries. This, so that people nurture their quantitative acumen, become more inquisitive and analytical, innovate and ultimately be better qualified to address problems of development as well as to convert accumulated knowledge into products and services of monetary value, so as to create wealth. Characterized as a deliverable, this goal can be achieved through a dynamic national Science, Technology and Innovation (STI) system of which science education is a major component.

Academies of sciences have a role in addressing what may be called the state of 'Science

Unappreciation,' at three levels; (a) By promoting science education in schools, (b) By promoting science education and scientific research at universities, and (c) By cultivating the culture of science within society.

This essay will briefly highlight some of the salient features of such a role.

Science Education: A Worldwide Interest of Academies of Sciences

At the 2000 Budapest World Conference on Science, the French academician, Pierre Léna (2004) emphasized the importance of education in science as a fundamental need of modern societies to achieve peace, justice and a sustainable development. It was Léna, together with Charpak (d. 2010) and Quéré who, under the auspices of the Academy of Sciences of France, launched the famous science education programme called *La main à la pâte*²⁸ (the hands-on or the hand in the paste), which eventually became a model for the involvement of academies of sciences in science education of children at the world level (Descamps-Latscha, 2003).

In the US, the National Academy of Sciences (NAS) played a major role in developing the National Science Education Standards, which were designed to make scientific literacy a reality in the US in the 21st century (Alberts, 1995). A further turning point in the narrative of science education, and science in general in the US, came with the publication in 2007 of

52 The author has used the term 'Education' in this paper, although the term 'Teaching' could be more appropriate in the final version of the same.

28 Launched in 1996, the French *La main à la pâte* programme aims to renovate and revitalize the teaching of science in primary schools. Supported by the Académie des sciences, and in close collaboration with the Ministry of Education, it has developed a new approach of science education, that has been recently integrated in national French curricula.

the famous report; *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (COSEUP, 2007). The publication addressed the S&T future of America, specifically, in the context of science education, and presented four basic recommendations which were encapsulated in catchy phrases, focused on actions in K–12 education (10,000 Teachers, 10 Million Minds), research (Sowing the Seeds), higher education (Best and Brightest), and economic policy (Incentives for Innovation) (NAP, 2010).

Some African Organization of Islamic Cooperation (OIC) academies such as the Ugandan National Academy of Sciences (UNAS) view science education as the single most important activity in which an academy of sciences can be involved (Mugambe, 2006). Moreover, some Asian OIC academies of sciences are quite active in the domain of science education including the Academy of Science Malaysia (ASM) (Ong and Abdul Rahman, 2002).

The interest nevertheless, shown by the academies of sciences of OIC countries in promoting science education does not match that of the world's leading academies of sciences. This is disappointing as implementing activities in science education is not normally a costly endeavor, as Shamsher Ali (Bangladesh) noted at the 1999 IAS Conference;

“ A pond with which students in many parts of the Muslim world are so familiar can be shown to be a living laboratory containing some of the local flora and fauna. Many biological lessons can be driven home to the students by simply analyzing the happenings in the pond. (Ali, 2000). ”

What the IAS does in the Domain of Science Popularization/Education?

The IAS has paid attention to cultivating a culture of science within OIC societies by organizing a series of conferences – with the decision-makers of the OIC particularly in mind – on science education policy. Such activities include convening its 1991 Amman Conference on ‘Science and Technology

Manpower Development.’ In 1999, it organized a conference on ‘Science and Technology Education for Development’ in Tehran (Iran) which analyzed many aspects related to the promotion of science education at all levels.

To encourage the young of today to develop an appreciation of, and delve into, the scientific enterprise with confidence, the IAS publishes journals and books that depict the outstanding scientific achievements, and portray some of the towering scientists, of the golden age of Islamic science. It has also published postcards carrying the portraits and brief bio-sketches of some such personalities.

By honoring scientific achievement and identifying champions of science, the IAS cultivates public interest in the scientific enterprise. In line with this objective, young scientists and young technopreneurs have been honored and their achievements publicized through a number of awards that the IAS has instituted.

Appreciating that an inextricable link exists between the wellbeing of science and the culture thereof in society and the realm of the history of science, the IAS organizes specialized seminars and symposia with help and support of other science academies as well as the UNESCO International Science, Technology and Innovation Centre (ISTIC) on themes emanating from the 2006 UNESCO History of Islamic Science, Engineering and Technology (HISET) Programme. The IAS has thus far convened such symposia in Malaysia, Russia and Qatar, that essentially aimed to unravel the mystery of the decline of Islamic science, and rediscover the milieu in which science in the Islamic civilization bloomed in the past.

Science Education: The Tip of the Proverbial Iceberg in Figures

To illustrate the problem quantitatively, some data on the quality of higher education and innovation is extracted from the Global Competitiveness Reports of 2014-2015 and 2010-2011 (WEF, 2014 and WEF, 2010) for a sample of four countries that basically represent the diverse grouping making up the Islamic world; Qatar, Malaysia, Egypt and Algeria.

Qatar, for example, is ranked an impressive

6th (out of 144 countries surveyed) in quality of math and science education (4th in 2010); 12th in capacity for innovation, a noticeable leap up from 45th in 2010; 2nd in availability of scientists and engineers (9th in 2010); and an excellent 8th in university/industry collaboration in R&D (27th in 2010). Needless to say the figures for Qatar speak for themselves. Malaysia, is ranked an impressive 16th (out of 144 countries surveyed) in quality of math and science education (31st in 2010); 13th in capacity for innovation, a noticeable leap up from 25th in 2010; 9th in availability of scientists and engineers (33rd in 2010); and an excellent 12th in university/industry collaboration in R&D (22nd in 2010).

At the other end of the spectrum, Egypt, which is considered the human resource reservoir of the Arab world, is ranked 136th (out of 144 countries) in quality of math and science education (125th in 2010); 132nd in capacity for innovation (109th in 2010); a reasonable 41st in availability of scientists and engineers (25th in 2010); and 133rd in university/industry collaboration in R&D (120th in 2010). Needless to say that the above assortment of indicators call for a serious review of Egypt's STI ecosystem, at the heart of which is science education at all levels.

Algeria, which unlike Egypt, has not experienced political turmoil during the last four years, is ranked 113th in quality of math and science education (84th in 2010); 143rd in capacity for innovation (125th rank in 2010); 61st out of 144 countries in availability of scientists and engineers (43rd in 2010); and 137th in university/industry collaboration in R&D (119th in 2010).

Scientific Research at the University Level in the Islamic World: A Précis of the Ideas discussed at IAS Meetings

Scientific research at universities is one deliverable of the process of science education that starts at the school-level and continues throughout the various levels of education. It is cultivated and nurtured in science-savvy societies.

In 2014, there were over 3281 universities in OIC countries (Webometrics, 2014) of which only nine were ranked among the world's 500 top universities according to the 2014 Academic

Ranking of World Universities (ARWU, 2014), with King Abdulaziz University and King Saud University (both in Saudi Arabia) as well as the University of Tehran and the University of Malaya, ranked highest.

Needless to say that universities must not aim for a higher ranking as an end in itself, and ranking systems should not dictate university policy but should be used as a source of information for guiding policies that are decided according to the needs of the university's own community, traditions, market niche, and national role (Shah and Kasim, 2009).

On the other hand, as the bulk of scientific and technological research in the OIC is carried out within the higher education system²⁹ (Naim and Rahman, 2008) and as ranking is essentially a reflection of the state of such research, then the picture for the Islamic world here appears bleak. OIC universities are not excelling in R&D, are not succeeding in producing knowledge workers to meet the needs of the globalized economy, nor are they contributing to the national socioeconomic advancement of their countries. Despite being confronted with globalization and the ascendance of private education, new knowledge and knowledge delivery modes, the higher education system within the OIC remains supply-driven.

To address the above quandaries, the following roadmap for action is proposed for science education at the university level, within the OIC;

(a) Sustained action is required that embraces academies of sciences to advise on strategies to upgrade higher education systems in OIC countries, elevate universities in the Islamic world to world-class level and advance the higher education system in general so that; it produces quality graduates that build knowledge economies, an R&D community that can address national problems and contribute to wealth creation through knowledge creation and innovation;

(b) Universities should not be an extension of the school system! As knowledge transmitters, universities in OIC countries must aim to form highly productive, work-ready professionals and not bureaucrats.

²⁹ In Egypt, for example, 65% of R&D is performed within the university system (ECIDSC 2009).

This requires admission policies of students and recruitment policies of faculty that are merit-based. The archaic hierarchical system of promotion and incentives at many OIC universities remains a hurdle;

(c) Research is the most salient example of a country's intellectual resources, economic strength and global competitiveness. Universities should be producers of research. OIC universities and research centers have been unable over the last four decades to develop a smart R&D environment. Rewarding R&D is slapdash. Faculty, often educated and trained in the west, do not implement the best research practices they picked up in the West. Lack of team spirit and comradery prevails among researchers and sabbatical leave is rarely used for research;

(d) Innovation is not yet part of the STI parlance in the Islamic world. This may be attributed to the weak linkages overall between private and public R&D, as evidenced by the low output of patents. Malaysia is the highest-ranking OIC country on the Global Innovation Index (33rd), followed by the UAE (36th), Saudi Arabia (38th), Qatar (47th) and Turkey (54th) (Global Innovation Index, 2014).

(e) To generate the public's interest in the scientific enterprise, universities should introduce or reintroduce courses and programmes in the History of Science particularly in the context of the Islamic Civilization as one means to engender appreciation of science among students. The ISTIC, the Malaysia-based center under the auspices of UNESCO, it is worth noting, has developed such a programme and has been active in this domain for some time.

(f) To encourage high school and young university students to become inquirers rather than learners (Pritchard, 2014), philosophy must make its formal entry back into school and university curricula at universities in the Islamic world. Furthermore, departments of 'Science and Technology Studies' (only one exists in the OIC in 2014 - at the University of Malaya) should be established at some universities in the OIC, to act as think tanks of science and technology policy issues within national STI systems.

Conclusion

It is fair to say that a mindset of 'Science Unappreciation' exists in the Islamic world raising the prospect of a multi-fold challenge for the science education community, including academies of sciences, to address. Firstly, there is the question of capacity building, i.e. how do we get school teachers trained and qualified to deliver science/ science education in a clear, concise and exciting manner and indeed with the required enthusiasm? Another important challenge that must be addressed by developing countries is the language in which science subjects are taught at schools. Would it be the local language or a universal language? This gives rise to the question of the availability of books and teaching material etc. in local languages.

Secondly, how can the impact of science education strategies be assessed quantitatively and how can the impact of science education on students and societies be measured?

Thirdly, when do we move as we should from Inquiry-based science education (IBSE) to inquiry-based education (IBE)? This seems to me to be a real practical problem. For how can we ask or expect young children who have, for example, just enjoyed a non-conformist IBSE class to switch back to a traditional mode of learning in a subsequent history or language lesson, for example. Shouldn't we start thinking of turning most of our education into Inquiry-based Education (IBE)?

A roadmap of action of action is required to upgrade science teaching at universities in the OIC as part of an extensive overhaul of the higher education system within. Science education at universities cannot be viewed independently of the national STI system of countries – particularly the human resource component thereof.

Lastly, academies of sciences worldwide can play a critical role in upgrading science education at all levels by sharing experiences and promoting practices conducive to an inquiry based learning environment.

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STEM Education and the Muslim Gender Divide

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When the announcement was made awarding seventeen-year old high school student Malala Yousafzai the 2014 Nobel Peace Prize, she was in a chemistry laboratory working on an experiment. She finished her school day prior to making herself available to the press. Perhaps we can hope for the day when many “Malalas” shall come forward in the Muslim world and consider their time in the laboratories an important part of who they are.

”



Nadia M. Alhasani

Dean of Student Life (formerly Dean of Women in Science & Engineering - WiSE) at The Petroleum Institute, Abu Dhabi, UAE

STEM Education and the Muslim Gender Divide

By: Nadia M. Alhasani

Professor and Dean of Student Life
The Petroleum Institute, Abu Dhabi, UAE

“If we’re going to out-innovate and out-educate the rest of the world, we’ve got to open doors for everyone. We need all hands on deck, and that means clearing hurdles for women and girls as they navigate careers in science, technology, engineering, and math.”

It may come as a surprise that this opening statement was made by First Lady Michelle Obama (September 26, 2011) on the status of women in STEM¹ in the U.S. It is a clear indication that the issue of STEM education, research and employment continues to be a major concern in many countries across the globe including those considered leaders in innovation². It is also apparent to many governments and non-government organizations (NGOs) that jobs in STEM reduce the income gap in general and the gender pay divide in particular, and increase a nation's economic growth³. These facts point to the need to reconsider the current trends in how STEM is perceived, practiced, and projected.

Muslim countries register the youngest population worldwide with up to 50 percent of its population below the age of 25.⁴ They also report the lowest scores in international math and science tests.⁵ Furthermore, Muslims' track record of inventions and innovations is also very poor. It is of interest to note that since its inception in 1901, the Nobel Prize for chemistry and physics has been awarded to three Muslim scientists only, namely Mohammad Abdus Salam (1979), and Ahmed Zewail (1999), and Aziz Sancar (2015).⁶ These numbers beg some fundamental intervention and change in current practices in regards to the development of more progressive STEM strategies for teaching, research and work

attainment.

The United Arab Emirates presents a unique opportunity to study and analyze many of the complex issues facing the Muslim communities at large. It also provides for some solutions that might be adopted elsewhere to further the status and advancement of STEMs within the society at large⁷.

According to a 2012 report on STEM education, “women in the U.S. earned 57 percent of all bachelors' degrees awarded, up from 54 percent in 1993. Simultaneously, the number of bachelors' degrees awarded to women in mathematics and statistics declined by 4 percent and in computer science by 10 percent. Consequently, while women have comprised a growing share of the college-educated workforce, their share of the STEM workforce has not increased. Only 14 percent of engineers are women, as are just 27 percent of individuals working in computer science and math positions.”⁸

In comparison, women in the UAE earned 62 percent of all degrees awarded in 2011-2012, reaching up to 71 percent in federal universities. In the STEM fields, women graduates represented 50.7 percent and 56.8 percent respectively. With the exception of engineering, women are graduating at higher rates than men in the STEM fields. As for the workforce, Emirati women constituted 43.8 percent of the workforce in 2011 up from 25.6 percent in 1990.⁹

It is worth considering these numbers within the context of the local job market. Given the young economy and dependency on oil, it became apparent to the UAE leaders that diversification in higher education is essential for better job opportunities. The Abu Dhabi Economic Vision 2030 was developed to become a comprehensive roadmap for all institutions, including academic, to build a knowledge-based workforce with a focus on

STEM and export-oriented sectors.

The late Sheikh Zayed bin Sultan Al Nahyan, founder of the UAE, had stated that "Islam affords women their rightful status, and encourages them to work in all sectors, as long as they are afforded appropriate respect."

To that end, Abu Dhabi National Oil Company (ADNOC) embarked on a unique endeavor by establishing the Petroleum Institute (PI) in 2001 to train young Emirati men in engineering and prepare them to work in the oil and gas sector. Five years, later, women were admitted to its programmes to attend separate classes in the same fields of engineering and applied sciences. To date, the PI has graduated over 1,000 engineers and scientists including more than 250 women. More impressive is the fact that 47 percent of all students pursuing bachelor degrees are women, of which more than 95 percent are Emirati nationals.

The operating strategies of the PI's Women in Science and Engineering Program¹⁰ (WiSE) stem from a fundamental shift in recruiting and retaining women in engineering and applied sciences as it acknowledges the fact that this generation of college students is quite different from their predecessors. What appears to be a lack of interest in basic sciences and mathematics is due in part to the degree to which students are exposed to science and technology. Today's Generation Y is a different generation from their predecessors, Generation X, or even the Baby Boomers before them.¹¹ While Baby Boomers are traditionalists working within clearly defined boundaries and are more willing to work in 9am-5pm jobs, Generation X enjoys freedom, incorporates technology and dislikes supervision. Meanwhile, Generation Y is motivated by flexible schedules and expects mentoring from their leaders. Finally Generation Z is the most connected and digitally experienced in communication and media technology. These characterizations are applicable across the world with varying degrees of exposure to science and technology.

Understanding the connection to and dependence of various generations on technology is crucial to ensure better recruitment results into the fields of STEM. Baby Boomers were fascinated with chemistry and physics labs given their limited exposure to technology outside school. They opened to a world that was only available in the

laboratories. However, Generations X, Y and Z have more exposure to technology with connection to the world outside the classroom. This access is also more available to both genders through cable TVs, home computers, and mobile phones.

Accordingly, a few initiatives have been implemented within the PI and local communities towards making STEM more of an attractive and attainable option to female high school students. These initiatives have evolved to become an integral part of the institute's strategic plans. Its application has also migrated to include the men as well with similar positive results. These include, but are not limited to:

Focus on the gender neutrality of STEM.

In most cases, high school girls see the traditional nerd image of a scientist or masculine image of a site engineer. The integration of technology in STEM fields has revolutionized the way we approach STEM studies and their applications. Physical sciences or math and statistics are abstract notions that carry the same concepts globally. Their fundamentals are universal and not place-specific. They carry the same meaning regardless of their application. Thus H₂O is a symbol for water whether in the east or west, and 1+1=2 regardless of the country of application. This universality coupled with that of technology is the key to teaching STEM and the advancement of its application.

Reveal the human aspect of STEM, especially engineering.

Many women, especially Muslims, are eager to serve their society through the medical fields in spite of the long hours, work shifts and work in remote locations or difficult conditions. There continues to be a mystery, due in part to lack of exposure, surrounding engineering. Much is needed to change the image of STEM towards making it an attractive alternative to business, for example.

Challenge students with innovative applications of basic STEM principles and extending imagination beyond standard projects.

In an era of collaborations and team work, this is an initiative that tends to be discarded by faculty who are less receptive to change. However, programs seeking international accreditation are more receptive to this initiative and willing to venture outside the box.¹²

Institutionalize community engagement of college students in STEM events.

Rather than the traditional service of university faculty supporting school teachers, first- and second-year STEM college students are leading fun and innovative activities engaging elementary and high school students towards raising awareness and igniting a passion for STEM, and in the process, contributing to the advertisement and advancement of STEM in the community¹³.

Distribute accolades through local and national STEM competitions to enhance the status of STEM in society.

A quick review of local news, both digital and in print, highlights the disadvantaged state of STEM fields in Muslim societies. A conscious balanced view between business and STEM should be considered in the media as they too have a social responsibility to advocate for STEM and highlight its crucial role in advancing the economy.¹⁴

Recommendations:

The low representation of women in STEM fields is a global issue in many countries including Australia, Canada, United Kingdom, and the U.S. However, there are countries with better records such as China where 40 percent of engineers are women. And while the number of women in engineering is declining in the U.S., it is improving in other countries. For example, the U.S. is behind thirteen Muslim countries in the percentage of women graduating with STEM degrees, including Bahrain, Brunei, Lebanon, Morocco, Qatar, and Turkey.¹⁵ Such success stories should be researched as case studies with the intent to consider knowledge transfer and sharing of experiences from one Muslim society to another.

Academic institutions are in a unique position

to work with governments and NGOs on science festivals, after-school programs and summer camps by mobilizing senior and graduate students. Community engagement and outreach has become one of the required factors that accreditation teams expect to see in STEM programs. Tougher federal and international accreditation requirements can support such initiatives and ensure minimum international standards of excellence.

A major contributing factor to the success of any STEM initiative is the reliance on teachers and professors to bring the excitement of science back to the classroom. Students are better inspired if there are those who can inspire them. Professors holding PhDs in STEM are not necessarily taught how to teach STEM. Innovative approaches to teaching, ensuring appropriate credentials and pedagogical competencies are essential to the advancement of modern STEM education.

Lastly, women must be included in all STEM initiatives to increase the STEM workforce. Muslim countries cannot afford to exclude half of the society if they want to catch up with the technologically advanced countries.

The vast expanse of Muslim countries, their diverse population, and varying resources must be at the forefront of any STEM discussions and strategy development. While the religion may be a unifying factor, the fact is that local traditions and cultural norms are major contributing factors affecting how STEM is perceived. Additionally, exposure to and familiarity with technology also varies across the Muslim world.

In his opening remarks at the 10th World Islamic Economic Forum in Dubai (October 28, 2014), the Malaysian Prime Minister His Excellency Najib Razak stressed the importance of giving education top priority in the Muslim world. He alluded to the historical significance of education in the Muslim world through its education initiatives and the world's first universities. "However, it has fallen back immensely as two out of three Muslims cannot read and write today," he said. These statements are an unfortunate reflection of today's state of affairs in a majority of the Muslim world, especially for women and young girls. The declining figures in literacy, in turn, affect how society perceives the importance of science and technology, and the role it plays

in an individual's development and society's advancement.

When the announcement was made awarding seventeen-year old high school student Malala Yousafzai the 2014 Nobel Peace Prize, she was in a chemistry laboratory working on an experiment. She finished her school day prior to making herself available to the press. Perhaps we can hope for the day when many "Malalas" shall come forward in the Muslim world and they will consider their time in the laboratories an important part of who they are.

Notes:

1. STEM, for the purposes of this study, refers to life and physical sciences (excluding medical sciences), manufacturing, prediction and construction technology, computing and engineering, as well as mathematics and statistics.

2. A recent survey of the top 100 innovative companies listed 45 U.S.-based companies. The listing is based on a study of a patent-related matrix. Thomson Reuters, 2013 Top 100 Global Innovators (October 2013). www.top100innovators.com/home.

3. According to a study by the U.S. Department of Commerce, "on average, men and women earn \$36.34 and \$31.11 per hour, respectively, in STEM jobs – higher than the \$24.47 that men earn and \$19.26 that women earn, on average, in other occupations." Women in STEM: A Gender Gap to Innovation. A report by the U.S. Department of Commerce-Economics and Statistics Administration. By David Beede, Tiffany Julian, David Langdon, George McKittrick, Beethika Khan, and Mark Doms (August 2011).

4. The Muslim countries discussed in this study are limited to members of the Organization of Islamic Cooperation (OIC). The association of 56 Muslim countries "promotes Muslim solidarity in economic, social, and political affairs."

A recent study entitled The Future of the Global Muslim Population, published by the Pew Research Center's Forum on Religion and Public Life (January 2011), projected the population of Muslim-majority countries by age groups. The age group 0-29 was 68% in 1990, 60.4% in 2010, and projected to be 50.4% in 2030. These numbers are based

on U.N. data and are weighted so that larger populated countries weigh more than smaller populated countries.

5. The Organization for Economic Co-Operation and Development (OECD)-Program of International Student Assessment (PISA) is an exam given every three years to 15 year olds around the world in reading, math and science. In 2012, 65 countries and education systems participated representing 80% of the world economy. The results for the eight participating Muslim countries, in comparison to selected countries in Asia (Korea), Europe (Germany) and North America (United States) were as follows (strikethrough-numbers denote a score below 400):

Mean Score in PISA 2012

	Math	Reading	Science
OECD Average	494	496	501
Shanghai-China*	613	570	580
Korea	554	536	538
Germany	514	508	524
United States	481	498	497
Turkey	448	475	463
United Arab Emirates	434	442	448
Kazakhstan	432	393	425
Malaysia	421	398	420
Tunisia	388	404	398
Jordan	386	399	409
Qatar	376	388	384
Indonesia	375	396	382

*Shanghai-China scored the highest in all three categories.

6. The Nobel Prize Muslim recipients in science are Mohammad Abdus Salam in Physics (1979) for his work on electroweak unification and Ahmed Zewail in Chemistry (1999) for his studies of the transition states of chemical reactions using femtosecond spectroscopy.

7. The United Arab Emirates has a population

of over eight million of which about 12 percent are Emiratis. It is projected that the country will need an average of 60,000 engineers for the next ten years to fuel its expanding and diversifying economy. This gap is exaggerated by the fact that only 30 percent of its young select the science track in public high school making the pool of applicant to STEM fields even smaller. It is of interest to note that over 50 percent of graduates from Dubai-based universities hold degrees in business.

8. STEM Education: Preparing for Future Jobs. A Report by the Joint Economic Committee Chairman's Staff, Senator Bob Casey, Chairman (April 2012).

9. UAE Economic Vision: Women in Science, Technology and Engineering. A Report from the Economist Intelligence Unit (2014). The research focuses on the status of UAE women in STEM. It includes the results of a detailed survey conducted in 2013 in which family and cultural norms are discussed against women's decisions to enter STEM fields.

10. The Women in Science and Engineering Program (WiSE) of the Petroleum Institute has witnessed a rapid growth over the past eight years in which the student population grew from 100 students in 2006 to over 770 in 2014. For a comprehensive study on the strategies leading to the growth, refer to "A Wise model for a WiSE program," by Nadia M. Alhasani in *Agendas for 21st Century Engineers*, edited by C. Brandt and D. Prescott (Newcastle upon Tyne: Cambridge Scholars Publishers, 2013), pp. 104-117.

11. Baby boomers are those born mid 1940-1960s (post WWII) with access to education that led to economic prosperity. Generation X are those born mid 1960s-1980s (who witnessed the end of the cold war, and the fall of the Berlin Wall) with exposure to globalization and acceptance of diversity. Generation Y are those born mid 1980s-2000 (also referred to as Millennials) with exposure to the latest technology that allows them 24/7 connection to the world. Finally, Generation Z

are those born after 2000 and are predicted to be immersed in technology and social media.

12. All reputable academic institutions are licensed and accredited locally and/or federally. However, there has been an increased trend over the last few decades in which universities outside North America seek licensing and/or accreditation for their various programs. While the main reason is usually to allow their graduates better access to graduate studies in the reputable U.S. institutions, the benefit can be seen locally in the manner in which programs carry out their curricular development and continued assessment. International accreditation has allowed academic management and faculty to establish an international base line to measure their performance against. Currently, most institutions seek accreditation for programs in architecture (NCARB), computer science and engineering (ABET), and business (AACSB). However, accrediting chemistry, mathematics, physics etc. seems to hold less interest outside North America.

13. The UAE has invested in a number of annual science initiatives targeting school children including the Abu Dhabi Science Festival and Dubai Think Science, to name but two. These events have been a magnet for students and their families to consider the event as a family outing while implicitly exposing them to a fascinating world of science.

14. Many opportunities have been established by the UAE government to develop and recognize students' interest in STEM innovation. Awards as Inventor and Expo-Sciences International are two such awards. The IEEE national chapter also runs annual student competitions open to all universities. These have created a competitive climate among engineering students to consider new ideas and applications.

15. Where Are America's Women Engineers?," By Tracey Schelmetic. Thomasnet.com, (February 19, 2013).

Science, Society & the University: 5 Propositions

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A fundamental purpose of the University is to shape, and constantly reshape, society. Just as society is reflected in the University, the University has the ability to shape society. It does this through the knowledge it produces, but much more by the habits of the mind that it instills in its students...[We must not only] focus on how we teach science, how much science we teach, but also – and importantly – what we teach beyond science. Especially, in how the humanities and social sciences are incorporated.

”



Adil Najam

Dean, Frederick S. Pardee School of
Global Studies Boston University, US

Science, Society & the University: 5 Propositions

By: Adil Najam

Dean, Frederick S. Pardee School of Global Studies, Boston University
Former Vice Chancellor, Lahore University of Management Sciences
(LUMS), Pakistan

Let us be clear on a few things, right at the outset: Science is not civilization. Science does not have a religion. Gravity comes from physics, not faith.

When we talk about 'Muslim Science', therefore, we're not talking about science that in some mysterious way is 'Islamic.' We are talking, instead, of science that is just science – hopefully, good science – but happens to emanate from Muslim societies.

A major challenge before universities in the Muslim world is that they often reside in societies that still view science in civilizational terms. Policymakers who wish to improve the quality of science education in the Muslim world have often focused all their attention and investment towards what happens inside Universities and ignored the societal conditions necessary for these investments to pay dividend.

This essay offers 5 propositions about science and society in contemporary Muslim societies. These relate, respectively, to how our understanding of the lessons of history, the essence of science, the reality of demography, the power of policy and the purpose of pedagogy have been mediated by how science, society and the University have come together in Muslim societies. Between them, these propositions suggest that the scientific barrenness of the Muslim World is explained not only by what is happening in our Universities, but by what is not happening in our society. The obvious implication, then, is that attention needs to be invested not only towards our universities but equally on Muslim society itself.

There is no claim that these are the only important propositions, nor is there the space to explore each at length. However, between them they are designed to make an argument for shifting our attention beyond the University; towards society; but most of all towards that interface between society

and the University. The contention being that policy will fail, or succeed at this interface; that science will blossom, or wither, also that this interface.

Proposition 1: History

Misunderstanding the so-called 'Golden Age' of Muslim science can have costly consequences

No discussion of Muslim Science can begin without the obligatory acknowledgement of the greatness of the 'Golden Age' of Muslim science. Let us also begin with that. But let us begin with the explicit recognition that the reason that the Golden Age produced great science – the science of Ibn-al-Haytham, of Al-Razi, of Ibn-Sina, of al-Biruni, of Al-Khwarizmi – is not because "their Islam" was somehow better than "our Islam," or because scientists then were somehow "better Muslims" than they are today.

Naïvely, maybe, but also dangerously, the popular narrative in too many contemporary Muslim societies implicitly imagines such a connection. Depending on the direction of the assumed causality, an Islamic revival is seen as a prerequisite to scientific resurgence, or science becomes the force that will lead to an Islamic revival. Missed in this muddled correlation is the real nugget of gold that can and should be derived from whatever histories of that golden age that exist. That for a variety of reasons – technology, wealth, reach, discovery, religious interpretation – Muslim society had opened itself to rationality, to inquiry, and to doubt. That as those windows closed on the Muslim world, so did the golden age. That the golden sheen which we so exalt, was as much in the society that produced the age as it was in its scientists.

It is not a surprise, then, that narratives that

begin with the adulation of that golden age, mostly end with calls to invest more in scientists or in making ourselves better Muslims. Both, of course, are desirable goals. But they miss the central lesson of that experience: that the goal of our investments is not just to produce good science, it is also to produce a society that can recognize, respect and respond to good science.

Proposition 2: Science

Good science comes from good questions; and good questions come from doubt and uncertainty

That a spirit of enquiry is central to the cultivation of good science is not a controversial idea. However, the corollary that such a spirit of enquiry requires a celebration of doubt and will be stifled in an environment of certitude can instil some agitation. Science is uncomfortable with certitude precisely because it is in the business of forever seeking new truths. Where religiosity undermines questioning, doubt and uncertainty, it can stifle the conditions that nurture good science.

This, of course, is not a challenge that is unique to Muslim societies. But it is a problem that we have long grappled with. Indeed, none other than the father of the scientific method, Abū 'Alī al-Ḥasan ibn al-Ḥasan ibn al-Haytham (or Alhazen), writing in the very early 11th century made the most persuasive case for the special place of doubt in the advancement of science:

Truth is sought for its own sake [but] truths are plunged in obscurity... the scientist is not preserved from error [nor] science from shortcomings and faults... Thus the duty of the man who investigates the writings of scientists, if learning the truth is his goal, is to make himself an enemy of all that he reads, and, applying his mind to the core and margins of its content, attack it from every side. He should also suspect himself as he performs his critical examination of it, so that he may avoid falling into either prejudice or leniency. (From *Doubts Concerning Ptolemy*, c1028CE)

A millennia later, this is still good advice. Universities in Muslim countries should widely share it with their students, faculty and beyond.

Proposition 3: Demography

The Muslim World is much larger than Muslim Countries

The term 'Muslim world' is mostly used to refer to Muslim countries. It should not be so limited in scope. Certainly not when talking about science and scientists.

Consider the following: Although an overwhelmingly Hindu-majority country, India is also home to more Muslims than any country in the world except Indonesia. There are, most likely, more Muslim PhDs, scientists and researchers who live and work in the United States and Europe than in any given Muslim country. Certainly, the concentration of the most eminent, the most prolific and the most productive Muslim scholars resides outside of Muslim countries. That would include, for example, all of the only three Muslim scientists to win a Nobel award: Dr. Abdus Salam (Physics, 1979; originally from Pakistan; lived and worked in the United Kingdom and Italy); Dr. Ahmed Zewail (Chemistry, 1999; originally from Egypt; lived and worked in the United States); and Dr. Aziz Sancar (Chemistry, 2015; originally from Turkey, lived and worked in the United States).

Arguably, the Muslim world's top scientists, best role models, and most valuable scientific minds do not live in Muslim countries. Even if some consider this an unfortunate reality, the reality is that the best 'Muslim science' today is happening outside of Muslim countries. It makes no sense to disown, disenfranchise, and discredit this great resource. Instead, we should embrace it. The best scientists will go – as they always have – where the best science is. More than that, new generations of Muslim scientists can emerge (are emerging) in non-Muslim societies.

In short, the assumption that the future revival of 'Muslim science' can only happen in Muslim countries is not only patently wrong, it is insulting to (too) many Muslim scientists.

Proposition 4: Policy

The University cannot not be a reflection of the society it is part of

Recent years have seen some welcome attention on the state of science in the Muslim

world. In certain cases, including in my own country Pakistan, this attention has also led to significant investments of policy and resources. That investment, however, has not shown much by way of return. At least, not yet.

The policies seem to be sensible ones: invest more money into universities, especially in the sciences; improve salaries of researchers and professors; send scholars abroad for advanced training; establish rewards for teaching and research; build norms for better university management; improve infrastructure; provide support to students; develop metrics and rankings to reward good performance. Yet, there is disenchantment with the results. The number of universities has rocketed, but their quality has slid. There are more publications, but also more plagiarism. All universities have better infrastructure, very few – if any – have better teaching. Far more people roam about with PhDs, but the scholarly discourse seems stagnant or falling. Trapped in a fetish of measuring quantity, we see quality slipping all around us. Rankings come up with weird results, junk science is put on a pedestal, ghost journals abound.

Some lay the blame on bad implementation, on cronyism, on ill-conceived incentives, and even on too much money being spent in too much of a hurry. All of this may be true, but also true is another lesson that is too often ignored. A policy agenda – no matter how well-meaning or generous – that ignores the readiness of a society to accept and embrace it, and invests no attention in creating that readiness, is doomed to stumble. Incentives will fail where there is no tradition of quality control. Performance indicators become meaningless when there is no culture of merit. Rankings become a joke if they can be easily gamed.

The lesson that the policymaker must never forget is that societal change is not something that can be assumed, it is something that has to be consciously willed, meticulously crafted, earnestly created.

Proposition 5: Pedagogy

The University has a duty to shape, and constantly reshape, the society it is part of

To summarize the previous four propositions: history tells us that glory requires not only

the brilliance of scientists but the support of society; science demands a society that values enquiry and celebrates doubt; the reality of demography is that Muslim society spans well beyond Muslim countries; and the lesson of policy is that without societal consent even the most well-meaning interventions will fail. If so, then who will bring about the societal readiness for good science that is so central to the success of the University?

The answer is obvious, although not intuitive: The University, of course.

Indeed, the contention of this proposition is that a fundamental purpose of the University is to shape, and constantly reshape, society. Just as society is reflected in the University, the University has the ability to shape society. It does this through the knowledge it produces, but much more by the habits of the mind that it instills in its students. This implies a focus on how we teach science, how much science we teach, but also – and importantly – what we teach beyond science. Especially, in how the humanities and social sciences are incorporated.

Teaching, in a University context, is as potent a tool for creating scientific excellence as research. In the context of scientifically less advanced societies, even more so. Yet, across the Muslim world, investments in advancing science in universities tend to be nearly entirely focused on research. As if a few people doing great science will turn the tide. The purpose of the university must be larger than that. It must be to create an entire generation, an entire society, that embodies a culture of enquiry. A culture, without which, even those few will not be able to do great science. The purpose of the University is more than just to produce good science; it is also to produce the conditions for good science to happen.

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Are universities of the Muslim world helping spread a culture of science through society?

“Attitudes towards Science, development, and religion tend to be complex. Islam, just like many other religions struggle with issues raised by advances in science and some of these issues include evolution and bioethics. However in some cases, Islam has facilitated scientific leadership...Universities across the OIC must engage on this issue and keep on dispelling the myth that Islam is not compatible with science.”



Ameenah Gurib-Fakim, FIAS
President of Republic of Mauritius
& Professor at University of Mauritius

Are universities of the Muslim World helping spread a Culture of Science through Society?

By: Ameenah Gurib-Fakim, FIAS

*President of the Republic of Mauritius
& Professor, University of Mauritius*

Since the eruption of Islam from the Arabian deserts in the 7th century, there have been repeated clashes between East and West and the West have systematically won this clash of civilizations, and one of the main reasons has been the superiority of Western Science, which has not always existed. Religious fervor was but one of many factors that helped establish the Caliphate extending from Southern Spain all the way to Afghanistan.

The Abbasid Caliphate was at the frontier of scientific development; the Arab world could boast to being home to the first true institution of higher learning – the University of Al-Karaouine in Fez, founded in 859. Building on Greek and Indian foundations, Muslim mathematicians established algebra (al-jabr in Arabic, meaning 'restoration') as a discipline distinct from arithmetic and geometry. Between the 8th and 13th centuries, while Europe stumbled through the dark ages, science thrived in Muslim lands. The 11th century 'Canon of Medicine' by Avicenna was a standard medical text in Europe for hundreds of years. In the 9th century, Muhammad Al-Khwarizmi laid down the principle of algebra – a word derived from the name of his book 'Kitab al-Jabr'. The first truly experimental scientist was Al-Haytam, whose 7-volume book on Optics exposed many misconceptions such as the prevalent belief that sight was made possible by our eyes emitting light. Abu Raihan al-Biruni, a Persian, calculated the earth's circumference to within 1%. Muslim scholars did much to preserve the intellectual heritage of ancient Greece; centuries later it helped to spark Europe scientific revolution.

The West owes a debt to the medieval Muslim world, for both its custodianship and classical wisdom and the age of new knowledge it ushered in, revolutionizing the disciplines of cartography, medicine, philosophy in addition

to mathematics and optics. These paragons of scientific thought are the forbearers of the Muslim and Arab world. Their great tradition is also our tradition, our history and our legacy. The English thinker Roger Bacon rightly noted that 'Philosophy is drawn from the Muslims'. Writing on the dispassionate process of scientific inquiry Ibn Al-Nafis said:

“When hearing something unusual, do not preemptively reject it, for that would be folly. Indeed, horrible things may be true, and familiar and praised things may prove to be lies. Truth is truth itself, not because [many] people say it is.”

(Ibn Al-Nafis, Sharh' Ma'na Al Qanun)

The question that comes to mind then is 'How did the Muslim world come to fall behind the West in the realm of Science? Why is it that OIC countries, with 70% of the world's gas and oil resources, 25% of the world's natural resources and 25% of the world's population, are left to trail the West. This is measured also in collective GDP's – the GDP of the entire Islamic world is estimated to be around USD 1,200 BN which is less than of France and quarter that of Japan.

Part of the answer can be obtained when one considers the statistics of the OIC's. Present statistics report that the Muslim world has only about 550 universities in all of its 57 OIC countries taken together compared to 8,407 Universities in India and with 1.2 Billion people. The United States, with less than 0.5 billion people, has 5,758 universities. Out of this 1.4 billion Muslims, 800 million are

illiterate (6 out of 10 Muslims cannot read). Large number of children in Africa and Arab countries are still shut out of classrooms with primary school participation at below 60% in 17 OIC countries. Illiteracy among Muslim women can be as high as 70% (Hepburn & Simon, 2006).

While resources were the chief factor behind booming economies in the OICs, it is a fact that learning and higher education are now the main driving force of world economies and the basis of socio-economic transformation of individual countries. Recent advances in Information Technology, Biotechnology and other emerging disciplines hold immense prospects for the wellbeing of mankind as a whole.

Yet most OIC member states do not have a sound policy for increasing investment in basic and tertiary education as well as scientific research and the translation of which is key for wealth creation. In 2005, Harvard University produced more scientific papers than 17 Arabic-speaking countries combined. The world's 1.6 billion Muslims have produced only 2 Nobel laureates in chemistry and physics (Nordin 2007). Both moved to the west and the only living one – Zewail is now based at the California Institute of Technology. The 57 countries of the OIC spend a puny 0.81% of their GDP on research and development – about a 1/3rd of the global average and contribute less than 1% to the world's scientific literature. America remains the highest spender with 2.9% and Israel lavishes with 4.4% (Naim & Atta-ur-Rahman, 2009).

In contrast, 95% of the new science in the world is created in the developed world, which comprises only 1/5th of the world's population and thereby owns most of the wealth of earth. This faulty vision has resulted in a number of problems such as low literacy rate, slow economic growth, increasing dependence on the West and transfer of resources from OIC member countries to the advanced world. Yet, history has shown time and time again that advances in Science and Technology are necessary prerequisites for political and economic strength – a lesson that we seem to have forgotten and rituals and dogma have replaced the true dynamism that previously existed in the Muslim world.

OIC leaders must understand that the exclusive

reliance on borrowed technologies from other countries can only impede development and progress. Investment must be made in scientific and technological research both in basic and applied sciences and in frontier technologies. These should be made an integral part of respective national development plans. Thus the real wealth of countries whether they are resource-rich or resource-poor remains the talented students and youths. It is through harnessing this potential that true progress will be made.

It is acknowledged that tremendous advances have been made in the fields of Science and Technology and that almost all facets of human existence – Communication, IT, Agriculture, Engineering have all been transformed by inputs from S & T essentially in the West. In these countries, policies have been put in place to translate research findings into processes and products as the leaders in these countries strongly believe that the cornerstone to their respective development program embraces S&T.

Similarly, it is therefore imperative that OIC member countries invest massively in education at all levels without neglecting basic and applied sciences. We should learn to shrug off this sick dependence that we have on the West for meeting all their needs such as IT, Machinery, Pharmaceuticals, etc.

For this to happen, the Muslim world should start by investing in the setting up of World-class Centres of Academic Excellence and Universities. The latter are institutions where knowledge is created and applied towards the development of new products and processes. Nonetheless, resource-rich OIC countries must realize that their wealth is not derived from physical assets like natural resource, but the untapped potential of their youth – both male and female. Their creativity must be unleashed through the right level of investment, sustained opportunities so that they can be given the chance to contribute to national development.

OIC Member states present widely differing scenarios in terms of Human capital, capital resources and infrastructure. Most of them are least developed and heavily dependent not only on foreign technology for most of their needs but even foreign aid towards budget support. While they espouse the wish to become self reliant, they sorely lack the necessary trained

human capital to maximally benefit from their extant reserves of natural resources.

Generally, richer OICs opt for expensive turnkey technology, buying whatever is available. This puts the West in a highly enviable position of technology producers with less developed countries as technology-consumers thereby enhancing the 'knowledge and technology-divide'. Often, the Muslim scientists who could ostensibly have developed these technologies are deprived of the opportunity to do so due to the lack of support research infrastructure in their home countries. Often these scientists would have moved overseas where they benefit from appropriate research environment from where they can operate freely and productively. In gauging the wealth or poverty of many OIC countries and the impact of technology, it would be pertinent to look at the input of technology in the economy of Finland. Here, where the GDP is measured to be US\$240, Nokia sales alone contribute to US\$26 BN, more than ten percent.

OIC countries should shy away from producing low value goods, as they tend not to help create wealth. The latter can only be created with higher end products from the technological sectors of industry such as pharmaceuticals; products coming from biotechnology, computers, software, products which essentially come from the West. Many such discoveries and development have emerged from University research, and more broadly from the environment of inquiry and innovation that these institutions foster.

Resource-rich countries can boast owning natural resources but transforming them into high value products is another ball game. The inquisitive, bright youngsters of these countries should be encouraged to join these areas of research. It is only when the education system inculcates critical and lateral thinking that such challenges can be tackled. However achieving that level of finesse requires strong academic leadership, which unfortunately many OIC countries sorely lack. Yet, there is no shortage of these strong leaders, OIC countries tend to be the most common victims of the brain drain to the developed world.

Fortunately, this caricature of the OIC endemic backwardness is being dispelled, at least in some countries. Countries like Qatar, Saudi Arabia are beginning to celebrate science

once more as the rulers are now realizing the economic value of scientific research and are trying to spend accordingly. Saudi Arabia has opened the King Abdullah University of S & T and has provided a 20Bn\$ endowment that even an American University would envy. Qatar has increased research funding from 0.8% to 2.8% of GDP – an amount that could translate to 5Bn\$ annually. Turkey is another key player with huge investment between 2005 and 2010. Iran is doing similar things.

However, it also worth highlighting that statistics only tells part of the story. R & D investment and publication rates do not capture the array of 'hidden' and non-traditional forms of innovation that occur in OIC countries. Countries in South East Asia have blazed the trail of social innovation. Bangladesh has pioneered the mainstreaming of microfinance, while Pakistan has used participatory mechanisms of development in making improvements to slum townships.

Strong leadership is needed and fortunately it is now starting to emerge in the OIC and gradually in the developing world. S & T related subjects with clear practical benefits are doing well. Agriculture, engineering, medicine and chemistry are popular and it clearly shows the mindset that value for money matters. Science is also helping to cross borders and some of the Middle East deepest divide. In 2000, the SESAME – an international physics laboratory with the Middle East first particle accelerator, was set up in Jordan. Modeled on the European's particle-physics laboratory – CERN, this set up is bringing together scientists from wartime foes.

The following key points summarize the key issues facing Universities in the Muslim world and how they are instrumental in promoting the culture of science, technology, entrepreneurship in universities and beyond.

Quality of Education

Prior to looking at Tertiary or University education, there is a need to take a closer look at the quality of education among boys and girls at a very young age. It goes without saying that there is a need to avoid learning by rote and reproduce facts with the sole aim of passing exams. Challenging the status quo through their learning process is critical.

Young children need to be taught discipline and to look up to their teachers and to respect them.

Children and scientists need to develop a critical mind and have the freedom to enquire, to challenge and to envision the unimagined. In education systems where rote learning is still the main method of teaching, the development of these critical skills can be stifled. In societies where authority is unquestioned and sometimes feared, researchers have limited capacity to question and challenge the status quo. Despite the fundamental importance of science and technology policy to a country's development, relations between the academic community and government are often weak.

The Place of Youth and Women

OIC countries have a key advantage of having predominantly young population and women account for 50.7% of the population (SESRI 2010). In the Arab region alone, some 60% of the population is under the age of 22 and compared to 28.4 for the global average. 13 Islamic world countries have produced more graduates than the USA in 2007. Whilst these figures are encouraging, the social pressures on these women remain and very few reach the higher echelons of the academic world (Sawahel 2008). There is a need therefore to empower in both intellectual and practical terms so as to become an 'essential axis' of the Arab project for a human renaissance (UNDP/RBAS 2005). Thus there is a huge demand for higher education and countries like Malaysia, Gulf States and Pakistan for example, have more than doubled their number of universities in the past 10 years. Perhaps the biggest expansion is to be witnessed in Iran where there are now more than 10x more young people in universities since 1979. As for expanding the university landscape, there is a critical need to accredit private universities, which have mushroomed in many countries. As the number of universities grows, so does the attention for the ranking in University league tables – often perceived to be an indicator of quality of teaching and/or research. Very few Universities of the OIC appear among the first 500 universities in the world (ARWU, 2009). The quality of teaching and research in Universities is therefore critical and institutions in the OIC have a key catch up role

to play.

Role of Culture

Science and Islam have proved to be compatible and religion can even spur scientific innovations. Accurately calculating the beginning of the Ramadan (determined by the sighting of the new moon) motivated astronomers. The Hadith (saying of Prophet Muhammad) exhort believers to seek knowledge, 'even as far as China'. However it is to be recognized that attitudes towards science, development and religion tend to be complex. Islam, just like many other religions struggle with issues raised by advances in science and some of these issues include evolution and bioethics. However in some cases, Islam has facilitated scientific leadership. Definitional differences over the stage at which an embryo becomes 'human' have enabled considerable freedom at centres such as the Royal Institute in Tehran, which conducts research using human embryonic stem cells (Al-Khalil 2008). Varsities across the OIC must engage on this issue and keep on dispelling the myth that Islam is not compatible with science.

Quality and merit in higher education

As soon as these youngsters leave high schools, they must be able to integrate Universities but purely on merit. The institution must also be a place where appointment and promotion are on merit and where there is accountability. These are the ingredients that promote transparency and work towards a culture of brain-gain. This is best illustrated by the approach used by Pakistan from 2000 onwards. Under the leadership of Prof. Atta-ur-Rahman, then Minister of Science, the research and higher education budget increased between 2400-6000% between 2004 and 2008. Enrolment increased from 135K to 365K. Investment in digital libraries and journal access provided greater access to intellectual infrastructure. This new initiative increased the volume of research papers and PhDs and improved the visibility of Pakistani research (Ur-Rahman 2010).

Centers of Excellence

OIC leaders have now started to provide the necessary funds to upgrade respective Universities and to promote a culture of excellence comparable to any internationally recognized Centre of Excellence. This initiative is reminiscent of that of Iran's 20-year 'comprehensive plan for science' with a large focus on higher education and academia. The establishment of a US\$ 2.5M Centre for Nanotechnology Research is one of the products of this plan. Among other commitments include the boosting of R & D investment to 4% of GDP and education to 7% by 2030 (Sawahel 2010). Malaysia is another country that has done exceedingly well among OIC countries through the vision of PM Mahatir's Vision 2020. There has been extensive investment in the Human capital and research and gradually results are tangible. In 2004, R & D personnel reached 31,000 and increase of 270% since 1998. Patents applications have grown and it remains the OIC country with the highest application across the OIC (OIC Outlook 2010).

Staff members and research students will be competing internationally to have their research findings published in journals of repute. Both basic and applied research needs to be carried out side by side as the former will generate new knowledge and data.

Governance and Policy

Of the 57 OIC countries, at least half do not have representative governments and rely on single party systems, royal families or military rules. Indonesia, the largest Muslim nation has a 10-year-old democracy. Saudi Arabia, recently held election and only men could vote. In the UAE, even though the royal families are quite generous to their citizens, the situation can be quite complex and at times limit the prospects for social and economic reforms. Yet the paradox is that those countries are those that have the strongest R & D. In Pakistan, for example, the period of military rules have been more supportive of science than periods when civilian administrations have been in power. Still the issue of freedom is unquestionable. Serageldine (2008) argues that science requires freedom as much as it requires investment and infrastructure as scientists need the freedom to enquire, to challenge and to envision the un-

imagined.

Translation of academic research and access to funds

Another important factor is concerned with the application of research and technology for industrial development and where interaction between researchers and the business community is called for. This close interaction with the private sector is weak not just in OIC but in the developing world as well. They have not been able to put in place a structure that would provide Venture Capital to entrepreneurial scientists nor have they encouraged any research to be carried out in industry. Yet this is key to wealth creation. The world may never have seen Facebook or Google has this system not existed in the USA. On a more practical scale, world-class basic or applied research remains thin on the ground. Where the research is of high quality, it is often directed towards local problems – unlikely to have a high impact internationally. One such example would be the removal of arsenic from potable water in Bangladesh. This encapsulates the pressing needs in the developing world and areas such as transport, urban planning, sanitation, biodiversity, primary health care and defence are areas where the research bases are often strongest (Johnston & Heijnen 2001).

Science and entrepreneurial policies

The final facet of development, albeit non-exhaustive, would involve the introduction of suitable government policies and mechanisms such as VC mentioned above to help those scientists-entrepreneurs emerge. Such measures prevent what is increasingly being referred to as 'stagnant technologies'. Often the laws surrounding Intellectual property are weak and also there are no tax or other incentives that would encourage private sector invest in promising academic research and development.

Conclusion

It is becoming increasingly apparent in the OIC and developing world generally that the culture of entrepreneurship, wealth creation through S & T involves many measures that would start from early school days. The child needs to be

empowered, develop critical thinking as well as learn to challenge the status quo. Freedom to think, act are closely linked. There are other issues that are equally important – collaboration with other centres of learning and centres of excellence, which are sine qua non for visibility of OIC science globally. Science diplomacy takes centre stage as well and helps to build trust among communities worldwide. Science can be a bridge to communities where political ties are weaker. Initiatives such as KAUST, Masdar in Abu Dhabi are leading examples on how they can woo leading international universities and research partnerships create a timely opportunity for Europe and the US. The soft power of science can be used to reach out to Islamic countries and further promote cooperation among common interests. It is increasingly being hoped that these projects, SESAME, for example, will help repair the fractious and bellicose relationships and inspire an entire generation of leaders, researchers, industry and academia.

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Science Education in the United States: Some Lessons Learned

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Every College Science

Course - be it biology, physics, chemistry, or earth sciences – should aim to enable students to gain a deep understanding of the nature of science. What is it that scientists do, and how does our broad consensus of how the world works (Science with an upper case S) develop from the many efforts of individual scientists (science with a lower case s)?

”



Bruce Alberts

Professor of Biology, University of California
at San Francisco & President Emeritus of
National Academy of Sciences (USA)

Science education in the United States: Some Lessons Learned

By: Bruce Alberts

*Professor of Biochemistry at University of California, San Francisco
& President Emeritus, National Academy of Sciences (USA)*

My strong personal interest in science education began in the early 1980s. At that time, my three children were young teenagers in the public schools of San Francisco, and I was a professor of Biochemistry and Biophysics in the medical school of the University of California, San Francisco (UCSF). Up to that point in my career, like most of my colleagues at the university, I had focused almost exclusively at educating graduate students and running my small research laboratory. However, my wife Betty had just been selected as the president of the Parents and Teacher Association (PTA) of San Francisco, a volunteer organization of parents devoted to supporting the San Francisco Unified School District. In that role, she would speak at nearly every meeting of the District's elected School Board. These meetings were held every two weeks on Tuesday evenings and broadcast on the radio. I became a regular listener and was disturbed by what I heard. There was almost no discussion on the serious issues of education: goals for student learning, the curriculum, or how to support teachers with training and resources. Sadly, to the detriment of both, the School District and my large, highly successful university seemed to exist on two different planets, even though we were only a few blocks away.

I decided that I would work to create productive interfaces between these two different worlds, a process that started with meeting with a group of the District's best science teachers to see how UCSF might help. This meeting led to the creation of a set of voluntary one-on-one partnerships between a District teacher and a UCSF scientist, in which each scientist was to serve as an adapter between the teacher and the university by responding to teacher requests for help with teaching resources (chemicals, equipment, organisms) or information (textbooks, expertise, training). Twenty-five years later this program survives

as UCSF's Science and Health Education Partnership (SEP; see <http://biochemistry.ucsf.edu/programs/sep/>).³⁰

While my focus in this article is on science teaching at the university level, not on science education for students of age 5 to 18, the above history is relevant, because it was from the many outstanding precollege science teachers I met through SEP that I first came to realize how little I understood about science education. Even though I had been teaching biochemistry at the college and graduate school level since 1968, I knew almost nothing about what experts in science education had learned from many cycles of curriculum development and research. In fact, I don't believe that I even knew that such research was being done. I was by no means unusual in this regard: nearly all of my fellow professors were equally uninformed. We all equated teaching with traditional lecturing, because those of us who became professors had gotten the A grades in science classes in which the students were merely passive listeners, and we quite naturally assumed that everyone could learn well in this way.³¹

College science classes define what is meant by the term “science education” at all lower levels.

Only much later did I recognize that a major rate-limiting step in improving the science education that students receive before college is how we define “science education” in the introductory college science classes that are taught in universities. In retrospect this should have been obvious. If, for example,

³⁰ “UCSF Science & Health Education Partnership,” n.d.<http://biochemistry.ucsf.edu/programs/sep/>.

³¹ Inquiry and the National Science Education Standards: A Guide for Teaching and Learning, The National Academies Press, accessed August 12, 2015, http://www.nap.edu/openbook.php?record_id=9596&page=R11#p200165cc99700xi001.

most first year college science courses in biology attempt to cover all of the material in a comprehensive text book of 1200 pages, this will set the standard for biology education at lower levels in that nation. Those lower level courses will likewise stress "coverage" and be a mile wide and an inch deep, lacking the kind of deep exploration of any topic that is needed to impart a sense of excitement and understanding. In fact, because there are many less words available for explanation in a lower level textbook, precollege courses often become little more than a march through huge numbers of word associations, with students being forced to memorize hundreds of meaningless phrases for their course examinations, such as "the mitochondrion is the powerhouse of the cell."

Fast-forward to the present, and it is difficult for any college science professor to plead ignorance with regard to the benefits of incorporating active inquiry into their teaching. In recent years, a very large amount of research has been carried out to compare the effect of traditional lecturing versus the inclusion of "active learning" in college science classes. Thus a recent article in the Proceedings of the National Academy of Sciences could analyze the results of 225 controlled studies of college science, mathematics, and engineering classes, finding that, average examination scores improved by about 6% in active learning sections, active learning sections, whereas failure rates decreased from about 34 percent to 22 percent. The authors thereby concluded that the results "support active learning as the preferred, empirically validated teaching practice in regular classrooms".³²

There are many open-access resources available for improving college science teaching.

Through the National Academies, the prestigious US National Academy of Sciences has published many book-length summaries of what we know about good college science teaching, all of them freely available as

downloadable PDFs on the web at www.nap.edu. (See, for example, Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering, 2012; Promising Practices in Undergraduate Science, Technology, Engineering, and Mathematics Education, 2011).

For those eager to improve their teaching, there are many sources of useful information designed to facilitate change. For example, since 2002, the open access journal CBE: Life Sciences Education has published a large series of "how-to teach" guides for college science teachers.³³ And for those who prefer videos to print, the iBiology website contains a series of concise talks by leaders in college science education reform³⁴ And essays and curricula from the 24 winners of Science magazine's two year contest for the best inquiry based modules for college science and engineering (IBI Prize) are freely accessible at its open-access web portal for education at <http://portal.scienceintheclassroom.org/>.

The small liberal arts colleges in the United States have long been leaders in exploring the best way to teach. But with typical class sizes of 50 students or less, they were often dismissed as not relevant to the much larger classrooms of a large comprehensive university. But we now have multiple models for the implementation of active learning in introductory science classes that serve over a thousand students per year. These include the comprehensive reform efforts led by Nobel-prize winning physicist Carl Wieman -- first at the University of Colorado, Boulder and then at the University of British Columbia.^{35,36}

And in 2010, the University of Minnesota opened a new science building with 16 flat, "no-lecture classrooms", in which several hundred

³² "Active Learning Increases Student Performance in Science, Engineering, and Mathematics," Proceedings of the National Academy of Sciences, accessed August 12, 2015, <http://www.pnas.org/content/111/23/8410.abstract>.

³⁴ (<http://www.ibiology.org/scientific-teaching/active-learning.html>.)

³⁵ "SEI," Home | University of Colorado Boulder, accessed August 12, 2015, <http://www.colorado.edu/sei/>.

³⁶ CWSEI, accessed August 12, 2015, <http://www.cwsei.ubc.ca/>.

students sit around a large table in groups of 9, sharing two or three laptop computers attached to the internet as well as to overhead projection screens. All introductory biology courses are now taught in this way, along with an increasing number of other science courses.

37,38

The analysis of 225 research studies that showed such positive results for active learning, referenced above, included much less ambitious efforts than those at the University of Minnesota. The research supports even modest changes in traditional lecturing that are easy to implement even in large lecture halls.³⁹

Perhaps the simplest modification to implement is the addition of "clicker" questions to lectures that are presented in a standard lecture hall. In this case, the lecture is interrupted every 15 minutes so to pose a conceptual multiple-choice question that requires student understanding to answer. After the students vote (using a device that resembles a TV remote), the results are immediately displayed electronically. The classroom then becomes very noisy, as each discusses the answer with several near-by neighbors. After a few minutes, the students vote again, invariably displaying an increase in their understanding. In the past decade, this modest form of active learning has spread widely throughout US universities, and it is being implemented for many different subjects, in addition to science and engineering classes.

As an example, a clicker question that I used in a course on cancer taught to a medical school class is presented below:

From what you know about cancer so far, would you predict that:

A). For most of us, our probability of getting cancer has little to do with the particular genes that we inherit; usually, cancer is instead the result of unlucky accidents.

B). The controls on cell proliferation would be expected to be such that, for the vast majority of our cells, no combination of a small number

of mutations could cause cancer.

C). Cancer at some level is inevitable, no matter what we do about avoiding exposures to harmful substances.

D). Elaborate new systems that control cell proliferation had to arise before a unicellular organism could evolve to produce multicellular organisms on the Earth.

E). All of the above.

Here the correct answer is E.⁴⁰

Good clicker questions are difficult to prepare but help can be found online. Research also strongly supports the value of group work in problem solving by students, as well as the value of direct feedback - not just course evaluations - for improving the way that faculty teach.^{41,42,43,44}

Active learning can be introduced with little cost, even for large classes

The scientist who narrates the previously referenced videos from the University of Minnesota, reports that the most important feature of her physical classrooms is not the computers and overhead screens, but the simple expectation that the students face one another (personal communication from Professor Robin Wright, University of Minnesota). This can be most simply accomplished by arranging all the chairs in a large room into sets of small circles. If available, round tables can be added

⁴⁰ Clicker questions: <http://www.lifescied.org/content/10/1/55.full>

⁴¹ Is Peer Interaction Necessary for Optimal Active Learning?, CBE-Life Sciences Education, accessed August 12, 2015, <http://www.lifescied.org/content/13/2/243.full>.

⁴² Feedback About Teaching in Higher Ed: Neglected Opportunities to Promote Change, CBE-Life Sciences Education, accessed August 12, 2015, <http://www.lifescied.org/content/13/2/187.full>.

⁴³ The Teaching Practices Inventory: A New Tool for Characterizing College and University Teaching in Mathematics and Science, CBE-Life Sciences Education, accessed August 12, 2015, <http://www.lifescied.org/content/13/3/552.full>.

⁴⁴ The Classroom Observation Protocol for Undergraduate STEM (COPUS): A New Instrument to Characterize University STEM Classroom Practices, CBE-Life Sciences Education, accessed August 12, 2015, <http://www.lifescied.org/content/12/4/618.full>.

³⁷ Interactive Classroom (2008) on Vimeo at: <http://vimeo.com/12050490>.

³⁸ Active Learning Classrooms (2012) on Vimeo at: <http://vimeo.com/41007436>.

³⁹ For a discussion of seven different options for incorporating active learning in a college science class, see <http://www.lifescied.org/content/4/4/262.full>

at the center of each circle. Dr. Wright feels that the second most important feature is providing a way for the students in each group to report out the results of their group discussions.

This can be done on whiteboards made out of inexpensive materials, such as the plastic-coated panels that are mass-produced for lining shower stalls. Instructions for constructing simple whiteboards are available on YouTube, including how to make large, low-cost moveable whiteboards for classrooms.⁴⁵

Although not essential, good connectivity to the Internet is required for the students to be able to solve problems using information available on the Web. Moreover, learning how to navigate this resource effectively to distinguish good information sources from non-scientific nonsense is an important skill for all educated adults. In many parts of the world, students will have cell phones that are capable of accessing the web, and their screens can be shared between two or three students to insure collaboration. In addition, it is becoming less and less expensive to outfit classrooms with the capabilities available in Minnesota. For example, this can now be done using I-pads plus standard projection equipment; if the same capability is not yet available for inexpensive Android devices, it soon will be.

In many universities in the United States, the large standard lecture halls are pre-equipped with commercial clicker response hardware, and each student is required to purchase his or her own interactive response device ("clicker") for use throughout the required 4 years of classes⁴⁶ The same device can also be used to take attendance and ascertain individual student engagement. A more recent development replaces the clicker with a web- or app-based classroom response system; in this case, each student's cell phone replaces the clicker hardware⁴⁷ No cost options include having the students raise numbered cards to answer multiple-choice clicker questions, or simply raise their hands.

One expert college science teacher addresses

active learning costs with the following insightful comment: "Most of the innovations featured are essentially no added cost - they simply require the professor to teach differently. Ask questions that require thinking, allow students time to think, remove declarative statements from Powerpoints and make students generate these statements. Then call on students at random after giving them time to think about, discuss, and formulate responses to questions; this will help ensure that everyone learns, not just the students who are most likely to answer questions."⁴⁸

Learning objectives: what is most important to teach?

I have thus far failed to discuss the critical issue of what exactly is to be taught. Obviously, it is meaningless to advocate for introducing more active learning in introductory college science classes in the absence of a framework for what it is that students should be learning: active learning for what purpose? Here I am on difficult ground if research is to be our guide. Research demonstrates the value of having one or a few central "learning objectives" for each class period – statements about the knowledge and skills that students should gain, which are clearly thought through and written down by the instructor in his or her initial stages of course design. But what exactly is most important for students to learn in any discipline is a matter for expert judgment -- and not all experts will agree.

Most broadly, I would argue that every college science course – be it biology, physics, chemistry, or earth sciences – should aim to enable students to gain a deep understanding of the nature of science. What is it that scientists do, and how does our broad consensus of how the world works (Science with an upper case S) develop from the many efforts of individual scientists (science with a lower case s)? By the end of any science course, students should be able to defend the statement that "science is a special way of knowing about the world" and to distinguish between scientific and non-scientific questions.

And I would like them to be able to appreciate quotes like the following:

45 See <https://www.youtube.com/watch?v=3s-uP-bVj4Vw>)

46 See for example, <https://www1.iclicker.com/products/iclicker-2>).

47 See for example, <https://tophat.com>).

48 Personal communication from Professor Erin Dolan, University of Texas at Austin

“The society of scientists is simple because it has a directing purpose: to explore the truth. Nevertheless, it has to solve the problem of every society, which is to find a compromise between the individual and the group. It must encourage the single scientist to be independent, and the body of scientists to be tolerant. From these basic conditions, which form the prime values, there follows step by step a range of values: dissent, freedom of thought and speech, justice, honor, human dignity and self-respect.”



(Jacob Bronowski, *Science and Human Values*, 1956).

Other core ideas will be discipline specific. Confining myself to biology, the field that I know best, different faculty will want to stress different aspects of biology in an introductory course, reflecting that teacher's passions and expertise. This fits with the fact that biology is a huge, ever-expanding field of knowledge, and only a portion this field can be taught effectively in the time available. And I am a strong believer in the “less is more” approach to education, since the frequent attempts to cover all of biology in a single year leave students with little sense of the science, and too often end up being little more than a race to memorize thousands of different science word definitions.⁴⁹

Nevertheless, it is generally agreed that there are at least a few core ideas that should be included in an introductory course. A recent attempt to outline such ideas for biology can be found on the College Board website.⁵⁰ This website describes the Advanced Placement

Course in US high schools that has been designed to match the best college courses in the subject. Analogous information is available from the same source for courses in chemistry, physics, and environmental science.

In closing, I would like to emphasize that, wherever possible, students should be forced to struggle with a problem before being told the answer. This is a very good way to enable students to understand the nature of science, as well as to get them to appreciate central scientific concepts.. Consider, for example, the topic of DNA, the molecule that stores all biological information for cells and for organisms, forming the basis for heredity. Many students fail to appreciate how amazing DNA is, because they have no idea of the huge intellectual gap that the discovery of its double-helical structure filled in 1953. Before that time, it was impossible to imagine how the great amount of information needed to produce an organism be “written” in the tiny space inside the cell nucleus, or how it could be so stably maintained over centuries despite the random chemical changes caused by the heat energy that acts on molecules over time. It may save class time to omit all of the history and rationale, but it can destroy most of the pleasure of learning.

⁴⁹ For a thoughtful review on college biology teaching by Professor William B. Wood, see <http://www.colorado.edu/sei/documents/publications/MCDB/innovations-in-teaching-undergraduate-biology.pdf>

⁵⁰ AP Central - AP Biology Course Home Page,” AP Central - Advanced Placement Scores, Courses & Exam Center | AP Central - APC Members Home, accessed August 12, 2015, http://apcentral.collegeboard.com/apc/public/courses/teachers_corner/2117.html?exc-mpid=MTG243-PR-21-cd.

Should Religion Be Kept Out of the Science Classroom?

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Going to the University should be made a unique experience in the life of a student from which he should draw inspiration for the remaining of his life. It implies the possibility of interacting with gifted teachers, scientifically and humanly... The least we should expect from a modern University education is that it endows the student with an inquiring even a doubting mind.

”



Jamal Mimouni
Professor of Physics at University of
Constantine, Algeria

Should Religion Be Kept Out of the Science Classroom?

By: Jamal Mimouni

Professor of Physics
University of Constantine, Algeria

The issue at hand is whether or not religion should be kept out of the science classroom in the Muslim world and in particular at the level of university education. This is a controversial subject in view of today's science legacy, as a result of centuries of successful practice, and in view of the dire state of science in the Muslim world today. I will first make some preliminary remarks dealing with science instruction in the University setting that will hopefully sufficiently contextualize the topic before dealing with the main problem.

Science Education and Muslim Higher Education

The Impact of science at the University leaves a lot to be desired

It is my strong belief that science education didn't create an impact of the desired degree on the minds of students in the Muslim world. This assessment can be readily confirmed when asking science and technology related questions to students; we most often receive answers that betray a marked ignorance of contemporary scientific thought.

It is not because students shun the sciences, on the contrary a rather large fraction of University students go in science related fields, as is the case in Algeria and in the Arab world. Somewhat paradoxically, students tend to have a positive attitude towards science and are often eager to learn about it; its wider implications like climate change, the wonder of modern medicine, science policy making and technology and its impact on the way and quality of life. It is an act of extreme negligence to fail to provide curious young minds with meaningful and attractive ways to approach these issues.

The fact that science doesn't percolate to students at large (the future decision makers!)

is worrisome because in a world where we increasingly rely on scientific logic to make decisions, a lack of capability and achievement for a country in this field, may delay the process of development in countries, perhaps even halting the process altogether. The lack of excellence in science also means ultimately the inability of Muslim academic institutions to leave their imprint on humanity's legacy in those neglected areas. Now, a country which does not leave some enduring imprint on science and technology can only be a considered a second zone country.

Even for science students, it is as if a dichotomy exists between what is taught and its accompanying values, and the world outside. They might specialize in a given field impervious to the wider picture and how their field may impact the economy and society at large. Of course, such a demarcation has always existed between academia and real life, but somehow bridges exist in developed countries, which efficiently erase this dividing line when students enter the job market. The fact is that most science students in our countries upon graduating won't make it to a profession in the field they chose and trained for. As for the students in non-scientific disciplines, they are strongly affected by what has been called the Two Cultures syndrome⁵¹ and this gap has to be addressed in appropriate manners.

Firing up imagination and producing inquiring minds

Going to the university should be made a unique experience in the life of any student from which they should draw inspiration for the remaining of their life. It implies the possibility of interacting with gifted teachers, scientifically and humanly. From this comes the importance of having well known academics teach large first and second year classes even

51 Snow, Charles Percy [1959]. *The Two Cultures*. London: Cambridge University Press.

if it is not what those teachers, quite advanced in their career, want to necessarily do. Of great importance too is favoring extra-curricular activities like acquiring extra skills, learning foreign languages, performing community work and the like, which should be made part of that higher education experience.

In my opinion, the least we should expect from a modern University education is that it endow the student with an inquiring, even a doubting, mind. As R.Feynman stated, "Science is the culture of doubt". Indeed, progress in science comes from constantly reassessing and challenging the knowledge one has acquired; the more vigorous the reassessment, the better.

A corollary to that lack of an incisiveness and inquiring mind is a widespread superstitious attitude that comes to exist among students, and gullibility is certainly not an intellectual quality. This includes magical thinking (non-causal behavior of objects and subjects), superstitions, and beliefs in out of body experiences, divination, and the like, all abhorrent to Islamic values. The propensity of many to invoke miracles "à tout bout de champ" must be replaced with an investigating attitude of seeking evidence by proper scientific methodology, genuinely seeking standard explanations. One has to add to this predicament the fact that in our countries the media scene is saturated with predicators often with superstar status, whose unreasonable if not irrational discourse on science and religion may further alienate people and deepen the problem. Quality education available for all should be put at the forefront of societal change initiatives, as it is the solution to not only a stagnating interest and aptitude in science but other challenges facing the developing world as well!

Another obstacle is the culture of rote learning; the tradition of "copy and paste" has created a mentality that is fostered in the minds of the students from a young age and is mistaken as "research work".

Should Religion be Kept out of the Science Classroom?

Is the Muslim world a special case?

This question of the place of religion in the science classroom needs to be tackled in the

context of the Muslim world where it is of particular relevancy. But let us begin by asking whether there is a Muslim specificity that makes religion a necessary ingredient in any debate related to culture, education, and society at large? True that in Islam, religious precepts strongly impact society at large and even if the secularizing trend in modern Muslim societies has taken its toll, this intertwining is very much present and perhaps more so than in any other society. It is thus legitimate to consider whether the religious dimension should be incorporated in the practice and teaching of science. In addition, one may argue that historically speaking there have never been in Muslim lands any conflict between science and religion unlike the case in the West where a warfare between both domains led to a total divorce.

This said, one has to realize that modern science has developed in this warfare context and it is difficult to imagine a situation where religion could be reintroduced. Yet, save for mostly the perennialist vision of a Sufi oriented thinker like Syed H.Nasr⁵² and his followers, no one is really talking about reintroducing spiritual teachings in science. What we are really talking about is a cultural approach whereby we contextualize science by injecting some religious precepts in the scientist's endeavor.

NOMA or SOMA?

One defender of this latter option is N. Guessoum for which he coined the term SOMA⁵³ (Softly Overlapping Magisteria) in contradistinction with the "hard" separation of magisteria NOMA (Non Overlapping Magisteria) as propounded by S.J.Gould. His starting point is that "...Muslims find it difficult to digest any "separation" of domains, widely believing that Islam is a complete system," that such a mild compromise would facilitate the

52 S. H. Nasr, "The Traditional Sciences, the Scientific Revolution, and its Aftermath" in *Religion and the Order of Nature* (Oxford University Press, 1996, Ch. 4, pp. 126-162.

53 N. Guessoum, "Nidhal Guessoum's Reconciliation of Islam and Science", *Zygon*, vol. 47, no. 2 (June 2012

acceptance of science by students.^{54 55} This is defended within the framework of reviving the Rochdian methodology in exegesis whereby any conflict between scripture and confirmed science is settled in favor of the latter with the understanding that the contending passage in the scripture needs reinterpretation. While I won't contest the usefulness of the Rochdian approach, and in fact I subscribe in large part to it, I think that its applicability is restricted to theological debates that one may have in an academic setting or during informal discussions with students. It is hard to imagine that it can be formalized in a somewhat unified way and institutionalized.⁵⁶

The difficulty is further compounded by a geographical divide within the Muslim world: the educational system in the Malay world and to some extent in the Urdu speaking one has incorporated this humanizing and contextualizing of science within the Islamic universe of values in their curriculum. On the other hand, in most of the Arab world⁵⁷ and in other parts of the Muslim world like in Africa, the Balkans, a much stricter division is been enforced closely following the Western curricula and with no foreseeable reconciliation.

It is perhaps useful at this point to state the author's position. I see the act of mixing religion with science a no-go endeavor, as it brings no benefit for either side. What I mean by this is not the kind of general statement or religious devotional formula that a teacher might utter to set the stage to his courses, or side discussions within the course itself, which routinely go on in the Islamic world⁵⁸, but rather about the encroachment

of theological considerations to naturalistic explanations⁵⁹. The point is that theological issues, except perhaps some concerned with ethical considerations on the borderline of the discussion, can't bring a cogent coherent view on those issues dealt with using the usual scientific corroboration methods as it doesn't have the tools or the authority for that. Any messing up with the separation of magisteria is bound to be detrimental to the proper dealing with the issues at hand. Now, upholding this concept may be difficult as many educators and opinion makers in the Muslim world are so used to concordist thinking that they naturally feel that proper Islamic world-view should be given and that the two magisteria should blend "harmoniously". It also doesn't have the favor of some secularists, and in particular of the atheists or agnostics kind, who may want to settle the scores with religion in an epic battle as empowering this principle robs them from their impending victory that a confrontation will, in their view, result in.⁶⁰

I believe that the adoption of the "Non-overlapping magisterial" principle in our Universities, in the natural sciences at least, corresponds to a middle way, as it is also crucial, when implemented, to efficient science education.

Bridging the Gap

We may try to soften the divide without crossing it. We may develop within the curricula bridging courses in the humanities and social

54 A. Berghout, *Revelation and Science*, Vol. 02, No.02 (1434H/2012) 85-94

55 *Islamic Cultural Identity and Scientific--Technological Development*, Klaus Gottstein, Ed., Baden-Baden, 1986

56 One has to remember that people have different views on the issue and that it is really like opening the Pandora box

57 Yet in detail, the situation much more patchy and needs qualification. The Gulf countries for example have a dual system.

58 Unstructured discussions or «religion chatting » which goes on at time when a student brings up a religious text in science class will have to be left to the appreciation of the teacher as it depends much

on his wisdom, capability to deal with the issue and the context. Ideally the general philosophy to adopt in such cases would be not to avoid the issue altogether which could leave frustration and hard feeling of «escapism » from the student, but rather to take it as an opportunity to review the scientific mode of inquiry in what it differs from the religious one, while at the same time pointing out to possible other explanations within one's the religious tradition. Finally, one needs to avoid concluding peremptory, rather leaving it as much as possible to each one's appreciation.

59 That's most clearly seen in the so called I'jaz trend of Koranic interpretation which purportedly claims to bring both together, and that even in some instances, religious texts could help choose the right scientific theory among competing ones.

60 Dawkins, Richard (1998). "When Religion Steps on Science's Turf", *Free Inquiry*. Vol. 18, Nb 2

sciences (History of science with an emphasis on the History of Islamic science, ecology with cross references with the Islamic teaching on the preservation of the environment as a religious duty...) so as to give a wider vision to science students than the narrow one they get out of their specialty.

Another corrective measure would be encouraging multidisciplinary studies for science students in particular. This is indeed one of the objectives of the LMD system⁶¹ adopted in Europe in the past decade and which many countries followed suit, most notably the Maghrebian countries. Yet for those latter countries, this truly revolutionary step only exists on paper and has never really been applied, as the so-called "passerelle" system is notoriously nonfunctional.⁶²

If we want to take the bull by the horns, and some way towards SOMA, specific courses on Islamic education can be developed so as to teach students Islamic core values especially on ethics and generally speaking on the Islamic vision of society and its higher goals, with some emphasis on the importance of a scientific and technological literacy. The point is that such "ideological" courses, even if taught by highly motivated and gifted teachers (Where are they?), might still be perceived by students as a burden and lead to a lack of interest in them. Such a compulsory course in Islamic ethics

was taught to the first year science students at Algerian Universities a few decades ago but it didn't achieve any measure of success as it became an extra load for students and was quickly phased out. Furthermore, it can be difficult to introduce such a course in the curriculum of private universities, where tuition money devoted on compulsory "fringe" courses not directly related to the diploma the students are seeking, is considered a waste. Clearly injecting Islamic and generally speaking ethical values in a University environment too often molded along Western patterns is challenging.

All these considerations need to be vigorously debated among educationists and academics, and we certainly don't pretend to have found the answers to the delicate issue set forth in the title.

61 Launched on May 1988 to mark the 800th anniversary of the Sorbonne and adopted in Bologna in 1999 by 29 European Ministers for Education the LMD's avowed purpose was to harmonize the architecture of the European system of education (including unifying European recognition of diplomas) so as to make it competitive with the American universities, promote the mobility of European students. Externally, it makes it similar to the Anglo-Saxon University system with its Bachelor (License), Master and PhD degrees.

62 The LMD requires considerable human and material resources as well as a rather advanced development of scientific research, all these prerequisites which are absent or problematic in the countries which followed suit. Thus its brutal implementation in those countries brought much trouble but ultimately when all the dust settled down, what was applied was a patchy system going by the European name of LMD, functioning as much as possible like the old so called "classical" system, but emptied from its most attractive features (extended the stays by students in labs at the Master level, multidisciplinary through a bridge system,...).

A New Approach to Incorporating IBSE/ STEM in School Curriculum in Arab Countries

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[In the late 8th Century]

Muslim world became the unrivalled intellectual centre for science, philosophy, medicine and education as the Abbasids championed the cause of knowledge and established a “House of Wisdom” in Baghdad... It is thus most logical that the new approach in IBSE/STEM curriculum for schools in South countries should have a pilot project in the Arab world.

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Dato' Ir Lee Yee-Cheong

Chair, UNESCO ISTIC

Chair, Science Education Programme (SEP) of
Inter-Academies Panel (IAP)

A New Approach to Incorporating IBSE/STEM in School Curriculum in Arab Countries

Dato Ir. Lee Yee Cheong

*Chairman, ISTIC Governing Board
& Chair of InterAcademies Panel's SEP Global Council*

Introduction

The decline in interest in science, engineering and technology (S.E.T) in the youth of both the developed and developing world has been a major concern of the global scientific community for several decades. This has resulted in declining enrolment in S.E.T courses in universities and tertiary institutions of education.

At the beginning of the last decade of the Twentieth Century, a pioneering call was made by Nobel Laureate Dr. Leon Lederman of Chicago for the scientific community to launch a "Learning by Doing" or "Hands On" initiative in primary school science and mathematics education in the poor African American regions of Chicago through his Teachers Academy of Mathematics and Science (TAMS). This "Learning by Doing" method is now known as Inquiry Based Science Education (IBSE) or in USA as Science, Technology, Engineering and Mathematics (STEM).

The success of his initiative led to the International Council for Science (ICSU) to set up the Capacity Building Committee to spread IBSE to the rest of the world. The founding Chairman was Dr. Leon Lederman. He was succeeded by Dr. Shirley Malcom of the American Association for the Advancement of Science (AAAS).

The InterAcademy Panel (IAP), which is the umbrella organization of the 106 national academies of science in the world, took over the global IBSE Program leadership from ICSU as IAP's Flagship Science Education Program (SEP) in 2001. In 2003, IAP set up the IAP SEP Global Council with Professor Jorge Allende of Chile as Chairman (2003-2007). He was succeeded by Professor Pierre Lena

of France (2008-2013). Under their dedicated and dynamic chairmanship, IBSE has spread throughout the world. The anchor has been in

large measure the La Main a la Pate (LAMAP) program of the French Academy of Sciences, established by the late Nobel Laureate Professor Georges Charpak, Professor Yves Quere and Professor Pierre Lena. To assure multi-stakeholder support in France, LAMAP has been transformed as the LAMAP Fondation with Professor Pierre Lena as the founding Chairman.

For further information about the important and impressive IAP SEP milestones set between 2001-2007 and 2008-2013 can be found on their website, interacademies.net.

I took over from Professor Pierre Lena as Chairman of IAP SEP Global Council in July 2013.

IBSE/STEM in the Developed World

By and large, IBSE has taken root in the developed world. In USA, President Obama is a national champion of STEM. The former president of US National Academy of Sciences and President Obama's Science Envoy to Indonesia and Pakistan, Dr. Bruce Alberts, is a tireless advocate of STEM at home and abroad. I have mentioned Dr. Leon Lederman and Dr. Shirley Malcom before. In the USA, education is within the State or local district purview, and there must be many innovative and thriving IBSE/STEM programs unbeknown to me.

In Australia, the "Primary Connections" program of the Australian Academy of Science and the STELR program of the Australian Academy of Technological Sciences and Engineering are spreading well. IBSE/STEM is in the Australian National Education Curriculum.

By far the most impressive growth is in Europe, propelled by the 58 academies under the Federation of All European Academies (ALLEA). Reference is made to the Executive

Summary of the Report "A Renewal of Science Education in Europe: Views and Actions of National Academies" by the ALLEA Working Group.⁶³

The Report noted the excellent progress of IBSE in France, Sweden and the United Kingdom. It drew particular attention to many European academies, participating as part of their national teams in European Union co-funded projects such as SciencEduc, Pollen and Fibonacci etc. The spread of IBSE/STEM to Eastern European countries is remarkable.

IBSE/STEM in Developing Countries

Compared to the developed world, IBSE/STEM has not really taken root in developing countries with the exception of a few countries, such as Singapore, Chile, China and Mexico. Besides dedicated national champions, most have had close collaboration with LAMAP.

In my opinion, most IBSE/STEM programs in the developing world are too dependent on the national academies of sciences. As a rule, many are poorly resourced and quite a few, too independent of government. The academies of sciences relate to ministries of science and technology whereas schools and teachers are under ministries of education. Thus their IBSE/STEM advocacy is indirect, intermittent and ineffective. The emphasis has been on getting the younger generation to aspire to be Nobel Prize winners and the like, rather than stressing that science, engineering and technology are critical in meeting the global challenges of poverty eradication and climate change. In the process, the relevant science, engineering, and technology (S.E.T) innovations will create widespread employment and reasonable income for the youth of South countries. The successful IBSE/STEM countries mentioned above all have ministries of education as partners, and the main drivers are not academies of sciences. They have passed the acid test of having IBSE/STEM incorporated into their national education curricula.

Very importantly, the priority in primary

education for developing countries is meeting the UNESCO "Education for All" target by 2015 as required by the UN Millennium Development Goals (MDGs). South countries have been having a very hard time merely building sufficient schools and training enough teachers to get all their children of school going age to school. It is universally accepted that every child has the fundamental human right of formal primary education. It is also universally accepted even by the most ardent advocates of science education that the prime objective of formal primary school education is teaching children to read and write and understand arithmetic.

Most South countries were former colonies of Western powers. Most of their territorial borders were drawn in the corridors of power in Europe, senselessly incorporating diverse ethnic, cultural and religious groups that had been at odds with one another for many centuries. Therefore, in their short histories of nationhood of much less than a century, the urgent task has been building the sense and reality of nationhood amongst their citizens. Thus school education must emphasize character building, national unity, national language, national history and geography, national culture, religion, civics etc. Of all the above, I consider character building to be the most important, as the developing world is desperately in need of an educated citizenry that is caring of family, community, country, continent and the world.

In such a crowded school curriculum in poor educational facilities in South countries, it is not surprising that science has to take a back seat.

In my opinion, the science education advocates of having science, and especially IBSE/STEM, as a subject in primary school curriculum in South countries are knocking their heads against a brick wall.

I now propose a new approach for South countries, starting with Arab countries.

The New Approach in IBSE/STEM in Arab Countries

The Islamic Golden Age is usually dated from the 8th century to the 13th century. During this period, scholars, scientists,

63 IAP - the Global Network of Science Academies, accessed August 13, 2015, <http://www.interacademies.net/File.aspx?id=21283>.

engineers, merchants and traders of the Islamic world contributed enormously to the arts, agriculture, economics, industry, literature, navigation, philosophy, science and technology, both by preserving and building upon earlier traditions and by adding many inventions and innovations of their own. Muslim philosophers, poets, artists, scientists, princes and labourers, created a unique culture that influenced societies on every continent.

During the Muslim conquests of the 7th and early 8th centuries, nomadic Arab armies established the Islamic Empire, the largest empire the world had yet seen. The Islamic Golden Age was soon inaugurated by the middle of the 8th century by the ascension of the Abbasid Caliphate and the transfer of the capital from Damascus to Baghdad. The Abbassids were influenced by the Qur'anic injunctions and hadith such as **“the ink of scientists is equal to the blood of martyrs”**, stressing the value of knowledge.

During this period, the Muslim world became the unrivalled intellectual centre for science, philosophy, medicine and education as the Abbasids championed the cause of knowledge and established a “House of Wisdom” in Baghdad. There both Muslim and non-Muslim scholars sought to translate and gather the entire world's knowledge into Arabic. Many classic works of antiquity that would otherwise have been lost were translated into Arabic and later in turn translated into Turkish, Persian, Hebrew and Latin. During this period the Muslim world was a cauldron of cultures which collected, synthesized and significantly advanced the knowledge gained from the ancient Chinese, Indian, Persian, Egyptian, North African, Greek and Byzantine civilizations. The Golden Age of Islam paved the way for the European Renaissance that ultimately led to the science and technology-driven global civilization of today.

It is thus most logical that the new approach in IBSE/STEM curriculum for schools in South countries should have a pilot project in the Arab world.

LAMAP “Decouvertes en pays d'Islam” or “The Discoveries in Islamic Countries”

I base the new approach principally on the LAMAP thematic book “Decouvertes en pays d'Islam” or “The Discoveries in Islamic Countries” in English (called LAMAP Book) written by Professor Ahmed Djebbar with pedagogical contribution from Cecille de Hosson and David Jasmin from LAMAP. The book was written as an expertly and pedagogically designed “learning by doing” text for French schools and is now well tested there.⁶⁴

Prof. Djebbar shows how the history of Islamic science and technology can be turned into a pedagogical tool for IBSE/STEM in schools. For LAMAP, Prof. Djebbar has built ‘learning by doing’ modules around ten “scientific” topics related to discoveries made by outstanding Muslim scientists during the Golden Age of Islam. The LAMAP Book is complemented by a website with a teacher's folder, showing links to explanations (and more) on each of the discoveries used in the book, namely Al-Farisi's model of the rainbow, Al-Khazini weighing scale, Ibn al-Nafis's discovery of the pulmonary blood cycle, Al-Jazari's water pump, Ibn Al-Haytham's light and vision, Al-Khwarizme's astrolabe, Al-Kashi's decorative symmetry and Al-Khazini's balance of wisdom. The website contains a children's folder, showing animations for each discovery and wiki pages constructed by the children from their research, both experimental and bibliographical. It is a truly a marvelous IBSE/STEM educational set. The LAMAP Book is now available in English in Malaysia and in Arabic through the collaborative efforts of ISTIC Malaysia and the Islamic World Academy of Sciences Jordan. I particularly commend the “easy to do” experiments in the LAMAP book and the short animation of each of the ten topics on the website.

Alas, for me, the website and all its wonders are in French!

64 “Découvertes En Pays D'Islam,” Le Site De La Fondation La Main à La Pâte, accessed August 13, 2015, <http://www.fondation-lamap.org/fr/decouvertes-islam>.

Science and Islam

The program that really set me thinking about the new approach to IBSE/STEM in Arab countries is the 3-part BBC TV series "Science and Islam", anchored by the lucid commentary of Professor Jim Al-Khalili.

This wide ranging and comprehensive TV program reveals to me how intimately the religion of Islam is intertwined with the spectacular progress of science and technology in the Golden Age of Islam. The three parts of the series are available for free download from YouTube.⁶⁵

Professor Jim Khalili has since written a most readable book "The House of Wisdom: How Arabic Science Saved Ancient Knowledge and Gave Us the Renaissance", (Khalili Book) Penguin Book, 2010. The Khalili Book is also published under the title "Pathfinders". The Khalili Book describes the life history of each of the most outstanding Islamic scientific and technological pioneers in some detail and provides scientific and mathematical explanation illustrated with drawings of the associated innovation. The Khalili Book strengthens my conviction that one cannot separate the religion of Islam, S.E.T and everyday life in the Golden Age of Islam.

"1001 Inventions"

I next turn for justification to "1001 Inventions", an exhibition that uses modern computer based animation and audio visual devices and systems to construct a highly interactive platform for the promotion of scientific and technological innovations in the Golden Age of Islam. The exhibition is accompanied by the remarkable book "1001 Inventions: The Enduring Legacy of Muslim Civilization" of the UK Foundation for Science, Technology and Civilization. This book identifies, in an enjoyable, easy-to-read format, aspects of our modern lives that are linked to inventions by Muslims or were inspired by them in seven important areas of our lives, namely, Home, School, Hospital, Market, Town, World and Universe.

The book is now available in Arabic and has

a compendium volume for children "1001 Inventions and Awesome Facts from Muslim Civilization".⁶⁶

A New Approach of IBSE/STEM in School Curriculum in Arab Countries

My proposed new approach in curriculum design in schools in Arab countries is predicated on the fusion of S.E.T with the Religion of Islam and everyday life in Arab countries, using the Golden Age of Islam for inspiration. I believe the student's interest in S.E.T will be much enhanced if it is anchored in their own religion, culture and heritage. I am convinced that for South countries to lift themselves out of poverty and achieve economic development, they need to develop widespread basic infrastructure i.e. roads, schools, water, sanitation, irrigation, clinics, telecommunications, energy -- as well as small and medium enterprises (SMEs) for supply of goods and services. Without the above pre-requisites, indigenous industries cannot upscale, the economy cannot expand and foreign direct investment (FDI) will not come. This development pathway will provide adequate job opportunities for the teeming school graduates in South countries, including those in Arab nations. School education in Arab countries must provide the human capital required for this development pathway.

Consider for example Sudan. While I have no knowledge of the school curriculum, I am certain that the Islam religion must feature prominently. We should be able to insert Islamic discoveries and innovations in mathematics and astronomy into the curriculum design of the religion of Islam by explaining how S.E.T achievements in the Golden Age of Islam were designed to satisfy the needs of Islam for ascertaining the direction of Mecca and the times of daily prayer from every part of the far-flung Muslim Empire. Mosques could know the time so they could announce the call to prayer. Times of important annual events in the Islam calendar, such as when to fast in Ramadan, celebrate Eid or go on pilgrimage to Mecca could be anticipated. This need led to the making of many innovative Islamic time pieces, the most famous of which is the Elephant Clock

⁶⁵ "Science and Islam, Jim Al-Khalili - BBC Documentary," YouTube, n.d. <http://www.youtube.com/watch?v=qL41gX0fJng>.

⁶⁶ National Geographic Society (U.S.), 1001 Inventions & Awesome Facts from Muslim Civilization (Washington, D.C.: National Geographic, 2012).

of Al-Jazari. The "hands on" experiments in the LAMAP Book for school students that allow them to determine the latitude and longitude of Paris can be adapted for Khartoum. The chapter of the LAMAP book on the still for clean water and perfume can be related to the need of the faithful for cleanliness.

The Chapter of the LAMAP Book on Symmetry highlights the principles behind religious motifs that are so prominent in Islamic mosques, palaces and buildings. These motifs have become a world heritage. This can also be inserted into the school curriculum on culture or civilization.

The Chapter of the LAMAP Book on the Al-Jazari water pump satisfies the societal need for irrigation for enhancing food production in the growing populations of the Islamic Empire. His discovery of the conversion of rotary motion into linear motion and vice versa forms the basis for every form of transmission system in modern transport.

The Chapter of the LAMAP Book on the discovery of the principle of light and vision can become part and parcel of school curriculum on history by featuring the giant of science, Ibn al Haytham.

Similarly the fascinating subject of the Arab numerals can be rightfully related to the life story of al Khwarizmi. The arrival of the pivotal "decimal point" from India can be included in a travelogue highlighting the changing landscape from India to the Middle East and the Maghrib in the school curriculum on geography.

On medicine and physiology, the Chapter in the LAMAP Book on the pulmonary blood circulation system of Ibn Nafis can be added to

the achievements of Abul Qasim Khalaf ibn al-Abbas al-Zahrawi. In his medical encyclopedia, al-Tasrif, he introduced a staggering collection of over two hundred surgical tools, including the catgut for internal stitching that is still used in the simplest to the most complicated surgery today.

My own fascination with human flight induces me to include the tale of the first Muslim, and perhaps person, to make a real attempt to construct a flying machine and fly, namely Abbas ibn Firnas in the 9th century. He constructed a flying machine and mounted a hill. A large crowd gathered to witness his flight. He flew to a significant height and hung in the air for over ten minutes before plummeting to the ground, breaking the wings and one of his vertebrae. After the event, Ibn Firnas understood the role played by the tail, when birds land! Perhaps students can figure out the function of the tail on landing.

Relative to character building, the school curriculum in Arab countries should emphasize the importance of students having a broad outlook in all facets of everyday life by emphasizing that almost every giant of innovation in the Golden Age of Islam was a polymath, being at the same time, religious scholar, poet, astrologer, musician, astronomer and engineer etc.

Finally the most striking feature of the Golden Age of Islam was the embracing of knowledge from all civilizations -- with Muslims, Jews, Greeks, Indians and even Chinese working together to preserve ancient knowledge and improve and adapt it for the benefit of society. This spirit of harmony and tolerance is very much at the core of Islam.

Science Education in Universities in the Islamic World

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I'm convinced that the problem of science education lies in the schools and not in the universities. It is in the schools that the main scientific facts and concepts are taught...In several Muslim countries the curricula are being modified to conform with the religious thoughts. This ... will have a lasting impact on the children minds by convincing them that any scientific fact that contradicts the religion must necessary be incorrect. I, therefore, believe that it is urgent to counter this movement, which has been going for some years

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Mustafa El-Tayyab
President, Future University, Sudan
former Education Specialist, UNESCO

Science Education in Universities in the Islamic World

By: Mustafa El Tayeb

President, Future University, Sudan

How is science taught in Muslim universities? What are the languages being used? What are the credentials and pedagogical competencies of the professors? What textbooks are being used? What resources are available? Is there a reasonable balance between the offering of basic science programs (e.g. pure mathematics, theoretical/basic physics, etc.) and applied science programs? Are any science fields or topics avoided for cultural/religious reasons? Is the theory of evolution taught everywhere (and how)? These are some of the issues that this short essay attempts to shed light on. At the outset, we must underline the fact that a comprehensive study of some of these requires a detailed survey that falls beyond the objective of this essay.

The state of science and technology in the Islamic World has often been referred to as poor. Comparisons of the main indicators: the Global Expenditure on Research and Development (GERD), the number of scientists per million, the knowledge Economy Index (KEI) and the Global Innovation Index (GII), demonstrate that the Islamic World is lagging behind in science and technology.

According to the latest data on the Global Expenditure on Research and Development (GERD), released by the UNESCO Institute for Statistics 2014¹, the vast majority of the Muslim countries are below 1%, with the exception of Tunisia 1.03%, Malaysia 1.1%. Next is Turkey (0.86%), Iran (0.75) and Morocco (0.73%). Much more modest are the percentages of Egypt (0.43%), Jordan (0.4%), United Arab Emirates (0.49) and Lebanon (0.30%). Finally, other countries (Oman, Algeria, Syria, etc.) do not even reach 0.2%.

Another important indicator of the poor state of science and technology and its linkage to the economy is the Knowledge Economy Index (KEI)². Developed by the World Bank,

this indicator, with the highest value of 1, lists 142 countries in a descending order. Five

countries out of the 57 OIC countries are

among the top 50 countries; the first Muslim country is the UAE which ranks 42 followed by Bahrain 43, Oman 47, Malaysia 48 and Saudi Arabia 50.

According to the last Global Innovation Index 2014³, 10 developing countries are among the top 50 innovative countries. The list includes Malta (25), Cyprus (30), Malaysia (33), United Arab Emirates (36), Saudi Arabia (38), Mauritius (40), Barbados (41), Chile (46) and Qatar (47).

These figures, however, mask the fact that the Islamic world is not a region such as Europe, Asia or Latin America. It is in fact a conglomerate of countries spreading over three continents: Africa, Asia, and Latin America. Moreover, it regroups countries with varying standards of living. Among the countries with high living standards are the UAE, Qatar, Saudi Arabia, Kuwait, Bahrain, Brunei and Malaysia with per capita incomes among the highest in the world. There are many others with average per capita income such as Oman, Turkey and Iran. On the other end, there are many countries with low per capita income such as Sudan, Somalia, Yemen, Chad, Comoros and Eritrea.

Before we dwell into the problems of science education in the Islamic World, we must state clearly that science education is a global problem. Many industrialized countries are facing enormous difficulties in this field. They are witnessing a steady decline in the interest in science among students. They also suffer from an acute shortage of teaching staff. The famous report of the National Academies **‘Rising Above the Gathering Storm’**, commissioned by the American Government demonstrates the seriousness of the matter in the United States. To respond to these

challenges, they are developing new inquiry-based methods of teaching science in schools. Good examples are La Main A La Patte in France and STEM in the USA.

Universities (and schools) in the Islamic World are facing a decline in the number of students enrolling in science fields. They also suffer from a severe shortage of qualified staff. Most importantly, the students are not taught to think scientifically as stated by Bruce Alberts who said

“Rather than learning how to think scientifically, students are generally being told about science and asked to remember facts. I am afraid not only students are taught that way but the teachers too were taught that way”.⁴

Another important factor is that the oil-rich countries did not realize the importance of science and technology in their future economic development. Only lately that they adopted policies based on the realization that their sustainable development and progress depends on the application of scientific and technological knowledge and know-how in the various sectors of economy. Higher Education in the Islamic countries used to depend on a few excellent universities. With the increasing demand on higher education, governments launched new institutions of higher learning and encouraged the private sector to invest in higher education. As a result, new universities were established in all those countries both private and public. This large number of institutions requires a corresponding number of teaching staff especially in the fields of science, engineering and technology.

A close look at the teaching of sciences curricula shows that the curricula in Islamic World are not very different from those in western universities. In the biological sciences, for example, universities use the same scientific textbooks and references. For example, the most popular textbook for first and second level courses in Biology are the famous Campbell's Biology and Banaszak, L., (2000). Foundations of Structural Biology. Academic Press, San Diego. There are, of

course, additional textbooks or references in local languages.

To illustrate this fact, here are the topics in a typical Biology curriculum: Classification of living organisms stressing evolutionary relations as the bases for classification, speciation, Genetics, population genetics: covering genes, gene-environment interaction, variation, evolution, adaptation, natural selection, fitness, Research methodology, Biotechnology and recombinant DNA technology, cloning, tissue culture, applications of genetic engineering in agriculture industry and medicine. The same applies to earth sciences and geology where curricula include: geological times and the evolution of life through geological eras, Paleontology, theories about the evolution of life, Embryology and Comparative anatomy of Vertebrates. The same applies for all courses in chemistry and Physics.

Let us now examine and compare with the contents of the curriculum of biological sciences as taught in the University of Oxford: Cells and genes, Organisms, Ecology, evolution, quantitative methods, Adaptations to the environment, Animal behavior, Cell and developmental biology, Disease, Ecology, Plants and people.

One of the reasons why teaching of science in Muslim universities is similar to teaching of science in the West, is the fact that most of these universities adopted one of the British, French or American systems. Although most of the staff that exists in these universities is Muslim, but they have fostered their knowledge about Science in non –Islamic countries, some of them were graduated there and some have also done their post-graduate education there.

Although, in general, science is taught in universities in the Islamic world as it taught in the West, it is fair to say that the way in which the subjects are taught may differ from one country to another. It is noteworthy to mention that although the contents of science curricula is similar, there are notable differences in the methodologies used as well as some boundary conditions that the teachers find themselves unable to surpass. The teaching of science in the UK is now shifting from giving the students scientific facts to a mode whereby the students are taught how science works. Likewise, in Singapore, universities are now breaking away

from lectures as the classical mode of delivery; students now have all their courseware in their tablets or laptops, they study at home and come to the university to discuss and exchange.

The languages used in teaching Science are Arabic and English or Arabic and French simultaneously. Although English is still used in many universities, there is a strong pressure on these universities to shift to Arabic or other local languages. This is particularly true for undergraduate studies.

Usually the subjects of basic studies (physics, mathematics and chemistry) are essential and constitute 40% of the applied science and engineering programmes. This ratio is based on the understanding that, without a solid background in basic sciences, the performance of the students in applied Agencies and engineering tends to decline.

On teaching Darwin's theory of Evolution

In the recent past, the Darwin's theory of evolution was taught in many universities in the Islamic World. Even today, evolution is taught in universities such as the Moroccan Mohammad V University, the capital's oldest higher-education public institution. It is still the only one of its kind at a public university. What is remarkable and unexpected is the fact that evolution is offered as elective course within a Master programme in King Abdalla University for Science and technology (KAUST) because teaching evolution is banned in Saudi Arabia.

Evolution theory is also taught in a fragmented way at the undergraduate level in many universities in the Islamic world. In others such as Sudan, where it used to be taught as a full course, is now timidly taught in an integrated manner as a topic in biology. In most cases the theory of evolution is at the center of these topics. Many people do not accept it because they think it does not allow for their belief in Creation. The geological times and fossil records are scientifically acceptable but when it deals with the evolution of life it contradicts with their faith.

Medical Sciences deal with life. This is another point of conflict between what medical professionals were taught in medical schools and the beliefs and taboos prevalent in their

society relation to the definition of life. In all those situations, the teaching in Islamic countries is generally in sync with the way science is taught in the west. The difference comes when teachers-either by conviction or obligation-point to what they perceive as conflict with religious beliefs.

It is very rare though that reference is made to Muslim scholars such as Ibn Khaldun (1332–1406) and his evolutionary philosophy. In his famous *Al Mokaddima*, he wrote about the origin of life:

“...It started out from the minerals and progressed, in an ingenious, gradual manner, to plants and animals. The last stage of minerals is connected with the first stage of plants, such as herbs and seedless plants. The last stage of plants, such as palms and vines, is connected with the first stage of animals, such as snails and shellfish which have only the power of touch. The word ‘connection’ with regard to these created things means that the last stage of each group is fully prepared to become the first stage of the next group. The animal world then widens, its species become numerous, and, in a gradual process of creation, it finally leads to man, who is able to think and reflect. The higher stage of man is reached from the world of the monkeys, in which both sagacity and perception are found, but which has not reached the stage of actual reflection and thinking. At this stage we come to the first stage of man.”⁵

I am convinced that the problem of science education lies in schools and not in universities. It is in schools that the main scientific facts and concepts are taught. It is also true that in several Muslim countries the curricula are being modified to conform to the prevalent religious thought. This process is known as *Ta'aseel*, often translated as Authentication. This revision of the curricula will have a lasting impact on the children minds by convincing them that any scientific fact that contradicts the religion must necessarily be incorrect. I, therefore, believe that it is urgent to counter

this movement, which has been going for some years. One effective method is to introduce Inquiry-based Science Education (IBSE).

It appears that there is an urgent need to train schoolteachers to use the leading methods of science and math education. They will likely improve the level of understanding in students and consequently make it less difficult to graduate qualified in these quantitative fields. Conscious of this Future University, a private university of technology, decided to tackle the problem of science education at schools. They explored the various methods, used in different parts of the world, such as IBSE (France), STEM (USA), Microscience (South Africa, UNESCO). In close cooperation with the Ministry of General Education, the university organized a teachers training workshop with major support from the International Centre for South-South Cooperation in Science, Technology and Innovation (ISTIC). A total of 42 teachers from the 17 States of Sudan as well as participants from neighboring countries were trained. Several international organizations and Academies participated in this event; this included the Islamic Educational, Scientific and Cultural Organization (ISESCO), The World Academy of Sciences (TWAS), Sudanese National Academy of Sciences (SNAS) and the Egyptian Academy for scientific research and Technology.

The following international experts attended the Round Table and the Workshop: Pr. Adnan Badran, former Prime Minister of Jordan, Pr. Bruce Alberts, former President of the National Academies (USA); Dato Lee Yee Cheong, Chairman of ISTIC Governing Board, (Malays), Pr. Yves Quere of the French Academy of Sciences, Pr. Alec Boksenberg from Cambridge University, Pr. Mohammed Hassan IAP Co-Chair and R. Maurenzi, the Executive director of TWAS.

The most important development was the presence of the Minister of Education, not only during the opening ceremony, but throughout the Roundtable and the training workshop. From the experiences of other countries, we know that the introduction of IBSE takes time. It also requires continuous support for its sustainability. It is for this reason that

the presence of high-level personalities was necessary; it served to send the message that IBSE is an important matter. We also made sure that there was adequate media coverage to sensitize the public about IBSE. All these efforts ensured the success of the introduction of IBSE in the Sudan.

During the second stage of this initiative, which will begin in February 2015, we shall examine the possibility of introducing the Islamic discoveries in the school science curricula. The exercise will be based on the methodology developed by LAMAP⁶ and translated into Arabic by the Islamic World Academy of Sciences. The method covers the following topics: a) light and vision: al-Haytham. b) The discovery of pulmonary circulation by Ibn al-Nafis d) The theory of the rainbow by al-Farisi. e) The astrolabe or the heavens in your hand; Science and art: an example of symmetry; the invention of the water pump by al-Jazari. f) An introduction to the Arabic alchemy. g) The still and distillation of water and i) The discovery of the "balance of wisdom".

The overall objective of this initiative is to try and reconcile the young generation of Muslim pupils and student with science and demonstrate the essential fact science is a common heritage.

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Science Education in universities of the Muslim world: No longer contented to merely be bystanders!

“The time seems set for a radical shift in the education sector particularly driven from a non-Western, post-Enlightenment (not least the Islamic) perspectives...If avoidance of “usury” is a key to opening up an alternative thinking to the (failing) conventional financial system, the reinstatement of the “Trust” (al-Amanah) as expressed in the Qur’an (33:72) is the key to spur an alternative thinking for education.”



Datuk Tan Sri Dzulkifli Abdul Razak
President of International Association of Universities (IAU), fmr. VC of University Sains Malaysia

Science Education in universities in the Muslim world: No longer contented to merely be bystanders!

By: Dzulkifli Abdul Razak

President, International Association of Universities (IAU)

Creating a “radical shift”

In attempting to dwell on some of the issues related to education in general, and science in particular, it is prudent to seek guidance from some success stories in the Muslim world. From the Islamic viewpoint the shift in the financial world that has long been plagued with problems, if not crises, not unlike the education sector, draws an interesting parallel. Admittedly, some decades ago, terms like *mudharabah*, *muamalat*, *musharakah*, *sukuk*, *istisna'*, *takaful* and the like were regarded strange in the world of banking and financial services. However today these are globally accepted financial products and services that are shariah-compliant beyond the core markets in the Middle East and Malaysia. It has resulted in an average growth rate of 15-20 per cent per year over the past decade, while Islamic financial assets grew from less than \$600 billion in 2007 to more than \$1.3 trillion in 2012 (Sergie, 2014). It is said that the sukuk market has come of age with global sukuk issuance in 2014 is expected to be \$130 billion upwards from \$119.7 billion in 2013.

Yet another testimony is the second annual London Sukuk Summit held in June 2014 that witnessed the British Prime Minister, David Cameron, reiterating that his government wants Britain to become the first sovereign outside the Islamic world to issue an Islamic bond. The British “Treasury is working on the practicalities of issuing a bond-like sukuk worth around UK£200 million,” with the “hope to launch as early as next year.” (London Sukuk Summit, 2014). In fact the Summit was able to attract experts, practitioners, issuers, regulators and clients from the industry and institutions alike.

This came close at the heel of the ninth World Islamic Economic Forum (WIEF) in London as late as October last year where Cameron unveiled a £200 million Islamic Bond Plan making it the first non-Muslim country to tap

into Islamic financing. Cameron was quoted as declaring, “I want London to stand alongside Dubai and Kuala Lumpur as one of the greatest capitals of Islamic finance anywhere in the world.” (World Economic Islamic Forum, 2013).

In the wake of the 10th World Islamic Economic Forum (WIEF), in Dubai from 28-30 October 2014, a report by the Dubai Chamber of Commerce and Industry based on a recent study by Ernst and Young stated that global Islamic banking assets have registered cumulative annual growth rate of about 16 per cent during the period 2008-2012, reflecting “the radical shift from conventional financial system in favour of Islamic finance.” (Dubai Chamber of Commerce, 2014). It spans, among others, retail and corporate banking, private equity, and insurance, catering to more than a billion Muslims worldwide, in tandem with the rising awareness in many different countries.

Lessons from the financial success story

Arising from this, the question that we urgently need to investigate is what constitutes this “radical shift”, that occurred in the relatively short period of 40 years? And what can be learnt to fast track other similar shifts, especially in the areas of education? – Beyond just the Muslim world, but the world over (just like the financial system); and beyond the confines of predominantly science and technology-based teaching, at the expense of the so-called “non-sciences!”

Too be sure such a shift (radical or otherwise) will not happen if there were no efforts made to plant the seed of a shariah-compliant ‘tree’ in an area dominated by conventional financial system worldwide some 4 decades ago. Granted that its growth has been marked by constant fine-tunings to address the inevitable shariah challenge, but such is the nature of any

evolving system that is here to stay.

Secondly, the shift will also not happen if the shariah-compliant framework is not able to make a significant difference to the current existing system with the gaps and flaws therein in order to equilibrate more benefits to the vast majority of people in improving their quality of life – both materially and spiritually.

Lastly is the need for an alternative system that is not just a product diversification exercise (based on the same fundamentals) but anchored on a radically different principle as a foundation that is vital to the understanding and practice of Islam. It could be to eliminate "usury" (riba in general) as it is forbidden in Islam and to institute more just and fair socio-commercial transactions. The Qur'an after all mentioned riba in a number of verses (2:274-279, 3:130, 4:161, and 30:39) in comparison to the acts of charity. It is argued in juristic terms as one of the means to 'devour' the wealth of others resulting in an unjust and discriminatory system overall. That riba has no place in the Muslim way of life is made clear in the Qur'an (2:278-279): O you who believe, give up what remains of your demand for usury if you are indeed believers. If you do it not, take notice of a war from God and his Messenger. Accordingly, in the hadith, the Prophet Muhammad s.a.w. condemns the one who takes riba, the one who pays it, the one who writes the agreement for it and the witnesses to the agreement.

The recent global financial crises are evident enough to validate the Islamic principles that prohibit riba and contrasting it to trade (... but God hath permitted trade and forbidden usury. Qur'an 2:275). It has been noted that while conventional banking morphs beyond recognition, Islamic banks remained true to their ethical commitments, shielding them from the financial meltdown. In hindsight, the recent financial crisis has brought about a rare moment of reflection and critical thinking, subjecting the Islamic finance logic to a rigorous test like never before, and rendering it more robust to withstand other vulnerabilities. The current global financial chaos indeed can be regarded as a vital touch point to ascertain if the Islamic financial services can indeed act as a more reliable alternative to the conventional financial system.

Addressing "education without soul"

Bearing these invaluable experiences in mind, several parallels can be drawn to the existing education sector worldwide. For a start the education crisis is also unfolding, and thus presents an opportunity for an alternative system to emerge and co-exist with the conventional education system. This is imperative as a counter trend to the conventional system that tends to promote education as a "tradable commodity" in a way that the severely compromises the ethos of education, leading to what is currently perceived as "education without soul." Consequently, for all intents and purposes, education is now an industry – a big business in fact – that has further widened the disparities between those who can afford it and those who cannot. And analogous to riba it resulted in an overall unjust and discriminatory system of 'devouring' the future of the latter group belonging largely to the Global South, with many Muslim countries placed in the worst possible position.

Viewed from another perspective, modern Western education has lost its soul since the days of the so-called Enlightenment in eighteenth century Western Europe. This is the period of European cultural rebirth (the Renaissance) that relegates all things to the "almighty" human reason and knowledge that is the ultimate goal of the Enlightenment-Renaissance project. Anything which cannot be comprehended by rational human knowledge and its version of science was defied as meaningless or superstitious, hence discarded as "unscientific," backward and useless. The natural world therefore is solely deliberated on the basis of reason, without taking into account Christian religious perspectives. It is because of this Thomas Paine coined the term "Age of Reason" which in essence heightened the conflict between religion (Christianity) and the inquiring mind that wanted to explain knowledge through reason supported by physical evidence and tangible proof. Generally known as the scientific method, Isaac Newton used this 'recipe' to make many advances in the eighteenth century, with lasting "scientific" impact. It became the basis of the European cultural expression in a new world of knowledge where natural philosophy becomes natural (modern) science backed by

utilitarian philosophy (that is, all action should be directed toward achieving the greatest happiness for the greatest number of people as determined by its utility).

Newton became the ideal Renaissance man for his rendering of a mechanical and ordered (if soulless) universe, which is the hallmark of the Enlightenment. This later spreads to other fields of knowledge including the non-sciences such as psychology, economics, and political theory in affirmation of the Enlightenment way of reductionist thinking. Human progress becomes dependent on such knowledge with an uncompromising 'hostility' towards the influences of the Church. Yet, invariably some Christian theological understanding and principles still find their ways into the "new" sciences (including mathematics) of the Enlightenment.

The Muslim dilemmas

It is at this juncture that Muslims encountered at least two major dilemmas. One, the rejection of Christian belief and theology as championed by the children of the Enlightenment is not necessarily the rejection of the Islamic faith and values in relation to science since many discoveries of the so-called modern sciences can be traced back to the Golden Age of Learning under the Islamic rule of more than 800 years. Indeed, science and religion then have exhibited a high degree of congruency, and that most early Muslim scholars were polymaths who were equally conversant in religious issues.

Secondly, the period of 1000 years (from the late 4th century to the 14th century) conveniently (mis)labelled as the so-called "Dark Ages" by the West saw many non-European sources of knowledge appropriated by the West (without any form of acknowledgement). Is it not the 11th century Ibn Al-Haytham (recognised by the West as Alhazen) – ca. 965-1041, heralded as "father of the modern scientific method" – long before Newton came into the picture? Likewise the Islamic root of education is totally disregarded, in favour of Europe's oldest university in Bologna, established in 1088 (in spite of the fact the first functioning "university" in the world is based in Fes, Morocco in 859).

Not only are Muslims denied direct association with their own heritage and traditions in

education, which incorporate Revealed Knowledge as part of its scientific framework, the numerous contributions by Muslim polymaths in shaping the "new" frontiers of knowledge are virtually omitted by design. Just because Western Europe was trapped in the Dark Ages, the assumption was that no advances took place outside Europe. In other words, had Islamic scholarships and perspectives been factored in, the ethos of education would have remained strongly anchored on the "soul" as a means to not only to discover the physical world but also the spiritual world as a way to reach the Creator through an equally "enlightened" spiritual path without any form of conflict in the search for the Truth.

As exemplified in the Qur'an (21:30), which proclaims that God created every living thing from water – now a common scientific knowledge, it at once reaffirmed the existence of the Creator as the Giver and Sustainer of life. For in the Qur'an (16:65) it says: And Allah has sent down rain from the sky and given life thereby to the earth after its lifelessness. Indeed in that is a sign for a people who listen. Other similar passages in Qur'an include 6:99 and 50:9.

In a nutshell as we move into the post-Enlightenment period, there is a compelling desire for an alternative framework (including values, principles, philosophy and worldview) beyond that of the Enlightenment "narrow" construct. That is, if we are serious in mitigating the conventional education state of crisis being central to several other crises: economic, social, ethical and ecological as an outcome based on the dated and provincial concept of the Enlightenment as well as the ensuing Industrial and Scientific Revolutions. This in turn points to the "Trust" (al-Amanah) that all Muslims are bound to as stated in the Qur'an (33:72): Indeed, We offered the Trust to the heavens and the earth and the mountains, and they declined to bear it and feared it, but man [undertook to] bear it. And the verse ends with a statement that seems to characterise that state of affairs today, namely: Indeed, he was unjust and ignorant – no doubt what humans have created for themselves amidst all the crises given the parochial worldview of the Enlightenment.

Taking leadership the way forward

If avoidance of "usury" is a key to opening up an alternative thinking to the (failing) conventional financial system, the reinstatement of the "Trust" (al-Amanah) as expressed in the Qur'an (33:72) is the key to spur an alternative thinking for education. As Muslims are commanded to constantly reflect and deeply think as part of the "Trust" rather than to blindly imitate (Qur'an 8:22), it is vital to fully embrace God's Wisdom through knowledge (Qur'an 2:269: Allah grants wisdom to whom He pleases and to whom wisdom is granted indeed he receives an overflowing benefit) ranging from the discovery of quarks to quasars. More so when the blind act can predictably lead to a plausible collapse as expounded by Naomi Oreskes and Erik Conway (2013).⁶⁷ They forecast a wave of "second Dark Age on Western civilisation," in which denial and self-deception (zulm instead of amanah?) hold sway on the occasion of the tercentennial phase of the Western civilisation (1540-2073). They alluded this to a naive reliance on positivism and neoliberal, economic attitudes (namely, the "free-market fundamentalism") which assume positive, favourable outcomes in tune to the march of the market. It takes precedence in an ideological fixation on "free" markets that disabled the world's powerful nations in the face of tragedy, encouraged by the fossil fuel industry and abetted by the media, while the planet continued to further deteriorate.

As highlighted by the authors, the role of scientists who best understood the problem were hamstrung by their own cultural practices, which demanded an excessively stringent standard for accepting claims of any kind – even those involving imminent threats. The issue raised "is how we – the children of the Enlightenment – failed to act on robust information about climate change and knowledge of the damaging events that were about to unfold."

Taking this in its entirety, the time seems set for a radical shift in the education sector particularly driven from a non-Western, post-Enlightenment (not least the Islamic) perspectives. Thus far the search for an alternative to the crisis has proved to be

difficult (if not impossible) because we are totally (and blindly) immersed in the Western narratives to the extent that there is no space to imagine a solution that is potentially capable of mitigating, let alone eliminating, the sources of such crises in seeking for a more sustainability future.

It is therefore timely to nurture an alternative space by embarking on a critical systemic analysis of the current situation to be "benchmarked" against the intrinsic values and principles of education that is also shariah-compliant. It has to be aligned with the mission of maqasid al-shariah in the protection of life, balanced intellect, posterity and property as a way to navigate through life reflecting on life-long learning of the past, present and the future. This is well summarised in the Quran: The metaphor of the life of this world is that of water which We send down from the sky, and which then mingles with the plants of the earth to provide food for both people and animals. Then, when the earth is at its loveliest and takes on its fairest guise and its people think they have it under their control, Our command comes upon it by night or day and We reduce it to dried-out stubble, as though it had not been flourishing just the day before! In this way We make Our Signs clear for people who reflect. (Qur'an 10: 24).

No doubt this new effort would pose enormous challenges in dealing with the crises that the (collapsing) conventional education system has inadvertently caused. In this context it is worth recalling that when the alternative, if Islamic, finance system first appeared in the mid-1970s, it was deemed as a 'flash' in the pan; naively discounted as an inconsequential epiphenomenon of the oil bubble. To throw the shariah challenge into an arena of predominantly secular thinking (another product of the Enlightenment period) then, drew many criticisms from countless sceptics far and wide, not least from the Muslims themselves. The reality however is more optimistic, gaining widespread acceptance as a viable solution for the uncertain global financial system; although it is still work in progress being a young but bold initiative.

⁶⁷ Naomi Oreskes and Erik Conway, 2013, *The Collapse of Western Civilization: A View from the Future*.

Concluding Thoughts

Encouraged by this success story, can there be similar courage and optimism in casting a shariah-compliant education system within the next 4 decades (or less)? – given the many relevant lessons that can be dwelt upon. Or must we continue to remain comfortable as pale imitations of a system that is not only less desirable to the Islamic ideals; but more so at the verge of a predictable collapse in about the same time period?

To choose status quo is to disregard the ongoing dangerously precarious situation and to dismiss the following rebuke: Truly, the worst of all creatures in the sight of Allah are the deaf, the dumb, those who do not use their reason (Qur'an 8:22). Clearly, we are now at a crossroad to ensure that the Muslims are no longer just happy to play the role of passive bystanders while others are busy in (re)shaping the future of education, and reinventing science as it were. More pressingly, how do we respond

to the numerous open invitations in the Qur'an to use reasoning ability and intelligence in ascertaining the Truth (Qur'an 21:10, 38:29, 43:3, 47:24). And towards this end creates yet another "radical shift" by instilling back the "Trust" that we have unashamedly long neglected. Unless of course there are locks upon our hearts (Qur'an 47:24).

Clearly too, this requires pure dedication, courageous leadership and hearts, as well as hard work for the Qur'an maintains: Indeed, truly with hardship comes ease; truly with hardship comes ease. (Qur'an 94:5-6). Then: So when you have finished (with your immediate task), still strive hard; and turn all your attention to your Lord. (Qur'an 94:7-8). By then the breast is expanded, with burden relieved by Allah to accept the duty of calling, and the repute raised high. (Qur'an 94:1-4). Before all these, however, there is no doubt that we need to make good the Amanah as the key prime mover. Allah knows best.

Observed problems and proposed solutions for science education in global Universities

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I do not think that the aim of teaching about evolution should be to attempt to persuade students to accept the theory of evolution. Rather, I think it should simply be to enable students to understand the theory... even if they themselves do not accept it...

The best education challenges learners but it does not undermine them.

”



Michael J. Reiss
Professor of Science Education
UCL Institute of Education, London

Observed problems and proposed solutions for science education in global universities

By: Michael J. Reiss

*Professor of Science Education at UCL Institute of Education
University College, London*

The issue at hand and my own contribution

Recent decades have seen substantial increases in the number of universities worldwide, in the courses they provide and in the international movement of students for their university education. Such developments provide exciting opportunities for the next generation to learn, including learning about other countries and cultures and to contribute towards societal goals at both national and international levels.

At the same time, such developments have caused many to question what the role of a university should be (Barnett, 2011). Nowhere are these issues more pressing than in universities in the Muslim world. Those responsible for the education that such universities provide may seek to do so in ways that seem to pay little attention to Islam or in ways that are consonant both with Islam and with the ideals of the university movement, always remembering that the university movement had its origins in the Muslim world.

It is this issue – the relationship between Islam and the university movement – that I wish to address in this short essay and because I am providing a contribution to the task force on 'Science Education in Universities of the Muslim World', my context is the teaching of science. At the same time, I write as someone who is not a Muslim. Any worth in the contribution that I seek to make is therefore largely provided by virtue of the fact that I write as someone who, while familiar with generalist arguments about the role of today's universities and how best to teach science while being respectful of religious sensibilities (I am a professor of science education based in a university and I am a Christian minister), is not a Muslim.

What is the problem?

Focusing on problems can be a negative way of approaching issues. Nevertheless, there is a growing problem in how global universities understand their role. Put simply, the days have gone when the faculty and students in a university shared a common cultural viewpoint. Today's universities, especially if they are academically successful, increasingly draw their faculty and students not only from a number of countries but from countries where individuals differ in their personal values, in their religious affiliations and in the importance they attach to religion.

Often this diversity can be ignored in terms of any consequences this has for the functioning of the university – or simply dealt with via informal discussions in the time-honored ways that universities have allowed, even encouraged, discussion and debate (Andrews, 2009). However, in certain circumstances issues arise that are core to the teaching of a subject where to ignore the different attitudes, perceptions and interpretations that individuals hold is to inhibit learning and even risk inflaming the situation. A classic instance of this is the teaching of evolution and I will now concentrate on this, after some preliminary remarks on the relationship between science and religion, partly because it is something of a cause célèbre, partly because there is an academic literature on which one can draw and partly because I am not convinced that the way we currently deal with issues raised by the teaching of evolution is as good as it could be.

The relationship between science and religion

The sociologist Robert Merton characterized science as open-minded, universalist, disinterested and communal (Merton, 1973).

For Merton, science is a group activity; even though certain scientists work on their own, science, within its various sub-disciplines, is largely about bringing together into a single account the contributions of many different scientists to produce an overall coherent model of one aspect of reality. In this sense, science is (or should be) impersonal. Allied to the notion of science being open-minded, disinterested and impersonal is the notion of scientific objectivity. The data collected and perused by scientists must be objective in the sense that they should be independent of those doing the collecting (cf. Daston & Galison, 2007) – the idealized 'view from nowhere'.

Other philosophers of science and sociologists have built on such notions of scientific knowledge. Karl Popper emphasized the falsifiability of scientific theories (Popper, 1934/1972): unless one can imagine collecting data that would allow one to refute a theory, the theory isn't scientific. Lakatos (1978), informed by Thomas Kuhn's (1970) work on scientific paradigms, argued that scientists work within research programmes. A research programme consists of a set of core beliefs surrounded by layers of less central beliefs. Scientists are willing to accept changes to these more peripheral beliefs so long as the core beliefs can be defended. So, in biology, we might see in contemporary genetics a core belief in the notion that development proceeds via a set of interactions between the actions of genes and the influences of the environment. At one point, it was thought that the passage from DNA to RNA was unidirectional. Now we know (reverse transcriptase, etc.) that this is not always the case. The core belief (that development proceeds via a set of interactions between the actions of genes and the influences of the environment) remains unchanged but the less central belief (that the passage from DNA to RNA is unidirectional) is abandoned.

There is now a very large literature on the relationship between science and religion: a major overview is provided by Clayton and Simpson (2006) and the journal *Zygon* specializes in this area. Consider, first, the question of 'authority' and the scriptures as a source of authority. To the great majority of religious believers, including university students, the scriptures of their religion (the Tanakh, the Christian bible, the Qur'an, the Vedas, including the Upanishads, the Guru

Granth Sahib, the various collections in Buddhism, etc.) have an especial authority by very virtue of being scripture. This is completely different from the authority of science. Newton's *Principia* and Darwin's *On the Origin of Species* are wonderful books but they do not have any permanence other than that which derives from their success in explaining observable phenomena of the material world and enabling people to see the material world through Newtonian / Darwinian eyes. Indeed, as is well known, Darwin knew almost nothing of the mechanism of inheritance despite the whole of his argument relying on inheritance, so parts of *The Origin* were completely out of date over a hundred years ago. Equally, for all its power, the Newtonian understanding of the world is a partial one, one that breaks down, in particular, over small distances and at high speeds.

The theory of evolution

As with any large area of science, there are parts of what we might term 'front-line' evolutionary theory that are unclear, where scientists still actively work attempting to discern what is going on or has gone on in nature. But much of evolution is not like that. For the great majority of the scientific community, evolution is a well-established body of knowledge that has built up over 150 years as a result of the activities of many thousands of scientists. The following are examples of statements about evolution that lack scientific controversy (Reiss, 2013):

- All of today's life on Earth is the result of modification by descent from the simplest ancestors over a period of several thousand million years.
- Natural selection is a major driving force behind evolution.
- Evolution relies on those occasional instances of the inheritance of genetic information that help (rather than hinder) its possessor to be more likely to survive and reproduce.
- Most inheritance is vertical (from parents) though some is horizontal (e.g. as a result of viral infection carrying genetic material from one species to another).
- The evolutionary forces that gave rise to humans do not differ in kind from those that gave rise to any other species.

There is much about the theory of evolution that is intellectually attractive. For a start, a single theory provides a way of explaining a tremendous range of observations; for example, why it is that there are no rabbits in the Precambrian, why there are many superficial parallels between marsupial and placental mammals, why monogamy is more common in birds than in fish and why sterility (for example, in termites, bees, ants, wasps and naked mole rats) is more likely to arise in certain circumstances than in others. Indeed, I have argued elsewhere that evolutionary biology can help with some theological questions, including the problem of suffering (Reiss, 2000).

The theory of evolution is not a single proposition that a person must either wholly accept or wholly reject (Scott, 1999). However, for religious reasons many people reject much of evolution, although considerable diversity exists within Muslim countries as to how the theory of evolution is presented in textbooks (Asghar et al., 2014) and understood in society (BouJaoude et al., 2011). For many Muslims, the Qur'an precludes a full acceptance of evolutionary theory, in particular the ideas that all of today's life on Earth is the result of modification by descent from the simplest ancestors and that the evolutionary forces that gave rise to humans do not differ in kind from those that gave rise to any other species. For other Muslims, the theory of evolution is compatible with their Islamic faith and understanding of the Qur'an. The various positions are discussed at some length by Negus (2005), Edis (2007) and Guessoum (2011).

Worldviews

One approach that has found favor in recent years as an educational way of dealing with contrasting understandings about the world, when these are deeply held by individuals, is the approach of worldviews. The essence of a worldview, as the word itself implies, is that it is a way of conceiving and understanding the world that one inhabits (cf. Aerts et al., 1994). So, someone with an atheistic worldview is likely to believe that the world is morally neutral and that there are no ultimate purposes in life beyond those that we decide for ourselves, whereas someone with a religious worldview is

likely to understand the world and our purpose in it very differently.

The rejection, on religious grounds, of the standard scientific theory of evolution can profitably be seen not as a simple misconception that careful science teaching can correct, as careful science teaching might hope to persuade a student that an object continues at uniform velocity unless acted on by a net force, or that most of the dry mass of a plant comes from air as opposed to the soil. Rather, a student who rejects the standard scientific theory of evolution can be seen as holding or inhabiting a worldview that has a very different way of seeing the world compared to the perspective of evolutionary biology. The pedagogical significance of this comes largely from the observation that one very rarely changes someone's worldview, whether at school or university, as a result of a short sequence of teaching, however well taught, whereas one may indeed replace a misconception with an alternative understanding after a brief teaching sequence (Chinsamy & Plagányi, 2007; Reiss 2008). A learner is likely to have far more of personal significance invested in a religious worldview than in a scientific misconception.

Contrary to others (e.g. Williams, 2014), I do not think that the aim of teaching about evolution should be to attempt to persuade students to accept the theory of evolution. Rather, I think it should simply be to enable students to understand the theory. Furthermore, the argument is not that the theory of evolution, or indeed any other aspect of modern science that the learner may feel conflicts with their religious beliefs, is the truth; rather the argument is that the theory of evolution, or whatever aspect of modern science is at issue, is widely (not necessarily universally) accepted by the scientific community and so it is worth learners having an understanding of it, even if they themselves do not accept it. Indeed, a good understanding of the theory, when taught sensitively, can aid acceptance (cf. Winslow et al., 2011).

Conclusion

Universities, both in the Muslim world and elsewhere, are increasingly multicultural institutions. The tension for today's university is how to take account of learner diversity –

every good educator needs to be sensitive to differences in thinking among their students – while remaining faithful to the knowledge that the various disciplines have built up over time. The best education challenges learners but it does not undermine them. University education is a place to help students to thinking rigorously and critically and to introduce them to new ideas and, above all, to knowledge that is robust.

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The Need of Liberal Education for Science and Engineering

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In a complex world...
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cated person. The liberal arts education
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tions needed to handle the interdisciplin-
ary challenges our science and engineering
graduates will face.

”



S. Shoaib H. Zaidi

Dean, School of Sciences and Engineering,
Habib University, Karachi, Pakistan

The Need of Liberal Education for Science and Engineering

Shoaib Zaidi, Professor and Dean, School of Science and Engineering,
Habib University

Executive Summary

Cognizant of the pitiful state of tertiary science and engineering education in Pakistan, Habib University's School of Science and Engineering is a bold and essential, mission driven initiative to identify and implement strategies, philosophies and practices to improve this morass. An intertwined, contextualized liberal arts centric STEM education is our best hope for moving forward. Our graduates will have the competence to be globally effective and the confidence and awareness to understand societies and cultures to assess and identify needs and design and deliver relevant, sustainable solutions. They will be proficient in the practice of their disciplines but more importantly will be able to act at the interfaces with other disciplines and with societies.



Background & Motivation

Higher education has existed in Pakistan since before its creation. Punjab University, King Edward Medical College, NED Engineering and several other colleges were all started during before Independence in 1947. Even with this history, Pakistan ranks 127th in the 2014-2015 World Economic Forum's category of "Higher Education and Training". It must be noted that this pitiful situation still persists even after the industrious and well-funded efforts of Pakistan's Higher Education Commission since 2002. Much as we laud improvements, we slipped to 127th in 2014-2015 from 122nd in 2010 and 124th in 2012-2013. This is a crisis. One that has perpetuated for decades and engulfed our practices, our expectations, our imagination and perhaps the most damaging of all, our hopes. Clearly all is not well and something is missing.

What are the missing elements? Are our engineers and scientist being trained to meet their expected roles? Why do we take are best and brightest and subject them to substandard

and incomplete education? Are our graduates able to understand the needs of their societies or cultures? Are they aware of the ground realities and the resources? Can they work with individuals from other disciplines? Are they the instruments of positive change we sorely need?

Fortunately, today, we are able to learn from the experience and reflections of others. In the United States, identification that sole focus on engineering education was a key factor in limited the graduates effectiveness occurred several decades ago. These anxieties relating to effectiveness of engineers were proposed to be tackled by accreditation reforms amongst other efforts. ABET, introduced "Outcomes based Education" in 1997 with the promise of moving towards holistic education. Liberal arts education forms the core of many such initiatives. Such positions are stated in Stanford University's statements:

 **The mission of the Department of Electrical Engineering is to augment the liberal education expected of all Stanford undergraduates,** 

(<https://majors.stanford.edu/electrical-engineering/ee>)

Leading universities like Stanford and MIT espouse a holistic, liberal arts education. One where one's science and engineering education enhances skills developed through the liberal arts. There is promise in following such an approach.

Social Science and Humanities in Pakistan

Unfortunately, in Pakistan, the situation is dire. For several decades, the lesser able students have been directed towards social sciences and humanities. As these students graduated and became teachers, they encountered intakes of lesser able students. Social Science and Humanities are generally of poor quality and widely accepted as such both in academia and the wider society. Recent attempts to broaden higher education by including social sciences and humanities have been cursorily implemented. The quality of faculty is generally poor and students, conditioned by the expectations and habits of their elders, expend minimal efforts in such areas. In engineering schools, humanities and social sciences are considered peripheral or even distractive. The development of reading, writing, analysis, synthesis and expression, are neither expected nor demanded.

Liberal Arts in Science and Engineering in the United States

One noted feature of the American education model is its insistence of a broad education. Initiative's like ABET were intended to move science and engineering education in the right direction. Nearly two decades later, it is apparent that what happened at many engineering schools was mostly a remapping of the previous distribution requirements to meet new accreditation terms. They meet the letter but not the spirit of the intended reforms. What are thus needed are not just remapping, but reimagining of science and engineering education and how it connects with societies, cultures and communities. Schools that have internalized the importance of liberal arts for the science and engineering are the ones ascending in effectiveness, rankings and prestige. Harvey Mudd, Olin, Stanford and MIT all place great emphasis on holistic learning and engagement with the real world.

The Need for Awareness and Ability to Comprehend

To remain relevant in the fast changing world today, it is essential to practice as an effective scientist or engineer. Acquiring awareness of the needs, the resources, the outcomes, their impacts (both short and long term),

identifying the stakeholders, understanding their concerns, gathering and assimilating knowledge and content from varied sources, synthesizing this into a clear ideas, formulating implementable action paths, communicating convincingly to generate support are but a few of the skills needed. How many engineering or science programs focus adequately on ensuring such skills develop in their graduates?

Liberal Arts for Developing Essential Critical Thinking Skills.

An intertwined liberal arts education is the ideal companion to a rigorous science and engineering education for forming these essential skills in tomorrow's science and engineering graduates. Objective questions have a sole correct answer and the entire class is expected to reach the same destination. In contrast, social sciences and humanities demand individualized creative responses. It is not unfathomable to imagine two students, from identical backgrounds and education, even being identical twins, answering a social science question with widely varying ideas and support. Whilst one may focus on historical traditions, the other may offer economic motives as the reason. Both of the answers, if well supported and well presented may get the coveted "A" grade. Such situations for individualized responses are uncommon in typical science and engineering curricula. However, it is through such practice of individual thought that one matures critical thinking skills.

The Era of Complexity

We live in a complex world. Dealing with the richness and complexity of human experience is necessary for any educated person. The liberal arts education introduces a range of ideas from a vast array of disciplines. These build the foundations needed to handle the interdisciplinary challenges our science and engineering graduates will face. The capacity of viewing situations from several different viewpoints to understand the key issues and their underlying causes, identifying needed resources and the expense of acquiring them, executing the carefully planned implementations demand familiarity with complexity. Without

a thorough understanding of science and engineering, there is no effectiveness but with only an understanding of science and engineering, the effectiveness is inadequate.

In the United States, both the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE) have voiced the need for reforms in science and engineering education and articulated the paths forward. NAE's "Engineer of 2020" vision moves beyond ABET's "a-k" outcomes to educate holistically. The goal is holistically trained graduates who can understand their complex worlds and be effective in creating suitable solutions. NAS's efforts, especially during Dr. Bruce Alberts' tenure, to move towards inquiry based science education bolster such skills enhancement.

The Case for Liberal Arts Centric Science and Engineering Education

Habib University started classes in the fall of 2015. Unencumbered by legacy, it was able to survey and adopt from best global practices. For the School of Science and Engineering, as discussed above, there is overwhelming substantiation of the need for a liberal arts centric education. It is not enough just to have the required courses, as that is a common model, but much more important is the establishment of core institutional beliefs, where non-technical competence and interconnectedness are valued, championed and celebrated. These practices are true to the intention and spirit of ABET reforms and provide essential balance and reinforcing support amongst the liberal arts and STEM. This is the best way forward for not only Habib but also others mired in the stagnant model of yesteryear.

Contextualizing Liberal Arts - The need for addressing inheritance and clarifying identity

What makes Habib's approach even more special is the nature of our liberal arts. The issue of inheritance or rather the gaping vacuum of inheritance is common in education in Pakistan and elsewhere in the Muslim world. Government mandated courses in Pakistan Studies and Islamiyat have been

the norm for almost four decades in Pakistan. The content is sparse and does not always stand to academic or intellectual scrutiny and the implementation mostly cursory. Students are smart and they know when something is not being done with seriousness or rigour. Providing such education to the brightest fortunate few who get tertiary education does not address issues of alienation amongst our youth. There is clear evidence of radicalization occurring in our medical, engineering and business schools and one reason is the lack of truth and effort in teaching about one's inheritance and thus clarifying questions about one's identity. When this is not done, insidious ideologies find fertile environments to thrive and later, wreak havoc.

The Contextualized Habib Liberal Arts Experience

There is no doubt that liberal arts enhance the effectiveness of a STEM education but the liberal arts model of Habib goes further. It is contextualized to be relevant and addresses the critical importance of inheritance. Some salient features of the contextualized Habib core are described:

- The initial course "Rhetoric and Communication" develops the ability to read and comprehend sophisticated writings and ideas. This is the first time many of them have such exposure.
- "What is Modernity" analyzes modern life and helps our students understand their era. This is especially important for understanding post-colonial societies where today many Muslims reside.
- The emergence and formation of nation-states and our history are addressed in "Pakistan and Modern South Asia". Through such studies, they are better able to understand issues in society.
- Islam has a rich history that is studied in the two-course sequence of "Hikma I & II – History of Islamic Thought". It is not uncommon for one to experience a "History of Western Thought" or similar course at many great institutions in the West. The same

rigour, effort and diligence is expended on readings from Islamic sages and others who have shaped Islamic thoughts, philosophy and discussions.

- English is the medium of instruction for most of the affluent and the educated in Pakistan. This creates a distance and foreignness with their own language and literature, especially to its modern and contemporary writers and works. “Jehan-e-Urdu (The World of Urdu)” is designed to both familiarize and develop appreciation of Urdu in our students.

A more detailed description of the core is placed at the rear of this article.

Conclusion

A broad, liberal arts centric education is best for preparing our students to understand and competently navigate the increasingly complex world. Contextualizing such an education are opportunities to address important issues of inheritance. When inheritance is ignored, the connection with one's past is broken. Such vacuums and lack of knowledge allow insidious fabrications and myths to emerge and invent new dangerous narratives.

In Muslim and other post-colonial societies, the yearning for what can be called an identity is emerging as colonial shadows wane. During such transitions, turmoil is not unlikely. Thus it is even more important that the youth, the ones most likely to be incited and radicalized, are provided an education that through its contextualized and rigorous curriculum and pedagogy proclaims a rich inheritance and where knowledge of one's history and culture can withstand and overcome falsehoods.

Acknowledgements

Habib University is a mission driven endeavor where debate and discussion are the norm. There are many without whom I could not have had this awareness. Our President, Mr. Wasif Rizvi and the Dr. Nauman Naqvi, Dean of the School of Arts, Humanities and Social Sciences have unwaveringly championed contextualized

liberal arts education for Pakistan.

Our daily work can consume us. Dr. Athar Osama is the glue which has brought us together to think and to disseminate findings and recommendations about these important matters.

Habib University's Seven Forms of Thought

(Habib Liberal Core description compiled from documents produced and shared by Dr. Nauman Naqvi, Dean of Arts Humanities and Social Sciences and Director of the Habib Core)

Seven Forms of Thought/Action reflect the particular pedagogical vision and the character of the faculty of Habib University (HU). Below are brief descriptions and justifications of the Forms of Thought/Action that reflect and will govern curricular production at Habib. All students at HU are required to take a determined minimum of courses under each form of thought/action.

Historical & Social Thought (2 courses):

The unprecedented change in the pace of modernity and the growing complexity of modern society makes it imperative for historical and social thought to be studied and researched. All undergraduates have to take two courses under this Form of Thought.

Course 1: CORE 102: What Is Modernity?

No one in the medieval world thought they were ‘medieval.’ The belief that we live in a distinct period of human history – that of ‘modernity’ – sets us apart from all premodern peoples. It is thus imperative for understanding both ourselves and our world to ask the question: What is it to be modern?

The modern age has radically transformed all aspects of our lives, which is why the question of modernity has become a central concern across a range of disciplines in the arts, humanities and social sciences. This course is thus designed as a multidisciplinary study of key texts that illuminate the culture of modern

life, existence and society. Key themes covered by the course include the nature of power and politics, the creation of economy, the role of science, technology and the media, the impact of modernity on the environment and changes caused by modernity in the realms of religious thought and gender relations.

What is Modernity? is a gateway course for Habib University's flagship Liberal Core Curriculum. Through critical and intensive engagement with both classic and contemporary texts, students will gain a sophisticated understanding of both themselves and their world that will be further refined throughout the Liberal Core.

Course 2: CORE 201: Pakistan & Modern South Asia

Nation-states – including that of Pakistan – emerged in the region of South Asia in the middle of the 20th century. With a special focus on the emergence and trajectory of Indo-Muslim nationalism and the creation of Pakistan, this course is a conspectus of the modern history of South Asia from the colonial period, including the rise of anti-colonial nationalism and decolonization, to the Cold War and the contemporary period of turmoil and transformation.

Philosophical Thought (2 courses)

The study of philosophy has traditionally been at the heart of liberal core curricula. Philosophical thought serves to enhance both the rigor, and the reflective powers of the student, essential to concept-generation and innovation in all fields. Habib University's flagship two-semester course sequence in regional and global humanities, Hikma I & II, takes the students to the pre-modern and ancient worlds of philosophy, religion, literature and art that remain our heritage.

Courses 1 & 2: CORE 202 & 301: Hikma I & II – History of Islamic Thought

Bridging the students' crucial sophomore and junior-years, this sequence takes our students to the next level of humanistic study and conceptualization. The course takes an

expansive world-historical and global view of the region's rich heritage of Islamic thought in its intense and distinctive engagement with both Greek antiquity and the other Abrahamic traditions, and ambient regional traditions, such as Buddhism and the Bhakti. The course reads the rich texts emanating from this encounter in Muslim thinkers such as Al-Farabi, Avicenna, Suhrawardi and Mulla Sadra, as well as philosophically and spiritually rich Islamic poets, such as Rumi and Amir Khusraw. Though the course material is primarily philosophical and literary, it also engages material from history, politics and the arts.

Language & Expression (2 courses):

The development of linguistic and expressive abilities is widely recognized to be a key benefit of a liberal arts education. Communicative power is key to leadership and success across fields and disciplines. This is why eloquence in the broadest sense is one of the most highly valued benefits of a liberal arts education. The opening course in our Liberal Core is designed to develop the reading and presentation skills – written, oral, applicative and visual – that our students will need to excel at Habib University and beyond.

Course 1: CORE 101: Rhetoric & Communication

The command of language and the ability to communicate effectively in speech and writing is essential to leadership. This is why eloquence in the broadest sense is one of the most highly valued benefits of a liberal arts education. The opening course in our Liberal Core is designed to develop the reading and presentation skills – written, oral, applicative and visual – that our students will need to excel at Habib University and beyond.

Our curriculum nurtures our students' rhetorical abilities throughout their college career, especially through the Liberal Core. Rhetoric & Communication is designed to first identify the different aspects of expression and eloquence as distinct and essential abilities, and to develop and improve them through application and practice. Cicero says in his

classic text on rhetoric, *De Oratore*: “Since all the activity and ability of an orator falls into five divisions, he must first hit upon what to say; then manage and marshal his discoveries, not merely in orderly merely in orderly fashion, but with a discriminating eye for the exact weight as it were of each argument; next go on to array them in the adornments of style; after that keep them guarded in his memory; and in the end deliver them with effect and charm.”

The material, classroom experience, and exercises of Rhetoric & Communication are designed to cultivate all five of these critical abilities, together with sophisticated reading skills. Our students will learn to make their speech and writing a total rhetorical experience, allowing them to communicate as effectively as they can across a variety of media. Class content will focus on compelling and relevant texts broadly defined – essays, journalism, speeches, advertisements, websites, etc. – and chosen to elicit opinion and encourage discussion and debate. As they develop their powers of reading powerful texts, students will practice and improve communication skills through regular writing assignments, revision exercises, individual and group presentations, and the utilization of ‘alternative’ (non-traditional) communication media like websites and social media. Rhetoric & Communication will also feature the ethics of discourse and communication, so that tact and respect for the other become an essential part of students’ experience and understanding of rhetorical ability.

Course 2: URDU 102: Jehan-e-Urdu (The World of Urdu)

This course is designed to fulfill our commitment to the vernacular, as well as to reap the potential of modern Urdu literature and criticism to illuminate crucial aspects of our modernity. Jehan-e-Urdu is a pedagogically dynamic seminar that will rapidly advance students’ appreciation and knowledge of Urdu through engagement with powerful texts of prose and poetry selected to speak to the concerns of the student today, opening up Urdu as a living world of insight and thought.

Creative Practice (1 course):

Creativity is a way of thinking. Our graduates will have the freedom to explore their disciplines and others with a critical lens; they will be allowed to experiment and fail, and try yet again. It is through the rubric of creativity that success flourishes. Our students will innovate, and become problem solvers. All HU students are required to take at least one Elective course under this rubric.

Formal Reasoning (1 course):

Deductive thinking and reasoning is crucial across fields and disciplines in both science and engineering, as well as the social sciences and humanities. Students are taught to think logically, act logically, and ultimately do logically. Whether they are solving a math equation, or trying to understand a Macbeth soliloquy, they shall do so with reason. All students at HU are required to take a minimum of one course in Formal Reasoning.

Course 1: CS 110: Computational Thinking I

Computational Thinking I introduces students to the theoretical and practical aspects of some of the major ideas and breakthroughs in computer science. The course material emphasizes the nature of computer science as not just an exercise in mathematics and logic but a means to solve social problems that impact the daily lives of potentially millions of people across the globe. Complementary laboratory sessions develop skills in algorithm building that allow students to program a computer to implement and test their ideas.

Quantitative Reasoning (1 course):

Numbers and quantities are an essential part of modern civilization and its forms of knowledge. The ability to handle and operationalize large amounts of data, quantitative reasoning and analytical skills is a crucial life skill. We make all our students take at least one course in Quantitative Reasoning. HOW

Course 1: ENER 101/103: Energy

The quest for safe, secure, and sustainable energy poses one of the most critical challenges of our age. This will require sophisticated and well-informed social, economic and technological choices. This course aims to provide students with the tools needed to think intelligently about sustainability. They learn about several possible alternate energy sources including the scientific principles that govern their creation and application. The laboratory part of the course features hands-on experience with renewable energy devices including solar cells, windmills, hydrogen fuel cells, bio-fuel, bio-diesel, etc. Students are expected to create their own devices during the course, allowing them to connect theory to practice. The exposure to these experiments extends their fundamental knowledge of physics, chemistry and statistics. The course also expands on the topics of energy conservation, energy storage, energy transmission and energy policy.

Natural Scientific Method & Analysis (2 courses):

The development of scientific method and analysis is a crucial feature of modernity and its forms of knowledge, impacting not just the natural, but also the social sciences and humanities. The centrality of science and technology in the contemporary world is unparalleled in the history of human societies and cultures. Because of the obvious power of scientific thought to shape ideas it has been the foundation upon which notions of progress, modernity, and even freedom and liberty have been built since the end of the 18th century. To ensure the scientific literacy of all our graduates, all HU students will be required to take a minimum of two courses in Natural Scientific Method & Analysis.

Course 1: SCI 200: Scientific Method

How do we make decisions? How do we evaluate information? Should we trust all information? How do we recognize the limitations of a claim? These matters are not only for practicing scientists but form an important part of our daily lives. At a time when information is more easily accessible than ever before, how do we intelligently utilize available information in making choices? This course builds on the foundations of scientific methods of inquiry and works to apply them to our everyday lives. Utilizing a wide array of examples, it illustrates scientific methods and their applications.

Course 2: CORE 302: Science, Technology & Society

Science, Technology & Society is a critical interdisciplinary course which challenges advanced students with the central assertion that, in the words of contemporary philosopher of science Sergio Sismondo, “science and technology are thoroughly social activities.” The course will draw upon Science and Technology Studies (STS) to demonstrate that the production and practice of scientific knowledge and technological development is a social and an historical process in which both scientists and citizens play a key role. Students examine the ways in which scientific communities create and regulate methods, establish consensus, and uphold or challenge theoretical models and technological advancements. In addition, they critically analyze the social impact and meaning of scientific breakthroughs and technological advances in historical and contemporary contexts.

Task Force on Science at the Universities of the Muslim World Member Profiles

Tan Sri Dr. Zakri Abdul Hamid, Chair, Task Force on Science at Universities of the Muslim World

Tan Sri Zakri Abdul Hamid has had an illustrious career in academia, government, and diplomacy. He is currently the Science Advisor to Prime Minister Dato Najib b. Tun Abdul Razak of Malaysia. He also serves as the founding chair of Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services and also one of 26 members of the United Nations Secretary General's Scientific Advisory Board. Among other positions, Zakri Co-Chairs the Secretariat of Malaysia's Global Science and Innovation Advisory Council (GSIAC), and Chairs the National Professors Council, the Malaysian Biotechnology Corporation (BIOTECHCORP), the National Foresight Institute and the Malaysian Industry-Government Group for High Technology (MIGHT).

Prior to his current position, Dr. Zakri was the Director of the Institute of Advanced Studies (IAS) of the United Nations University (UNU) and Deputy Vice-Chancellor of National University of Malaysia (Universiti Kebangsaan Malaysia). He holds a Doctorate (1976) in plant breeding from Michigan State University.

Prof. Nidhal Guessom, Convenor, Task Force on Science at Universities of the Muslim World

Prof. Nidhal Guessom is a Professor of Physics and Astronomy at the American University of Sharjah, United Arab Emirates. He is also a science communicator, writing as often in general-public venues as in specialized publications. His writings and interviews have featured on Al-Jazeera, BBC, NPR, France 2, Le Monde as well as Gulf News, Huffington Post, and Nature Middle East. He is particularly interested in the relation between Islam and modern science; in 2011 he published 'Islam's Quantum Question: Reconciling Muslim Tradition and Modern Science'. In 2013 Guessom wrote a commentary in Nature showing the stark contrast between the state of Astronomy in the Arab world during the golden age of the Islamic civilization and criticizing Arab nations today for not investing more money into astronomy research, which he suspects "is being neglected because of the strongly utilitarian Arab Muslim approach to science." Prior to AUS, Nidhal worked at NASA's Goddard Space Center, then in Algeria and Kuwait. He holds a M.Sc. and Ph.D. degrees from the University of California at San Diego, USA.

Datuk Dr. Mohd. Yusoff Sulaiman, Co-Convenor, Task Force on Science at Universities of the Muslim World

Datuk Dr. Mohd Yusuff Sulaiman is the President and CEO of the Malaysian Industry-Government Group for High Technology (MIGHT). MIGHT is an agency that represents a unique private-public sector partnership created to harness technology for business under the Prime Minister's Department. Dr. Sulaiman is a fellow of the Academy of Science Malaysia and the ASEAN Association for Engineering and Technology. He currently serves as Head of the Joint Secretariat for the Global Science and Innovation Advisory Council chaired by the Prime Minister. He sits on the Board of several Government-linked companies related to automotive, aerospace, green technology, high tech park, technology funding and nurturing. Dr. Sulaiman holds a PhD in Manufacturing

Engineering and specialises in technology management.

Prof. Bruce Alberts, External Expert to the Task Force on Science at Universities of the Muslim World

Dr. Bruce Alberts is biochemist with a strong commitment to the improvement of science and mathematics education and is currently Chancellor's Leadership Chair in Biochemistry and Biophysics for Science and Education at the University of California, San Francisco. Bruce was recently awarded the National Medal of Science by President Barack Obama. Dr. Alberts served as Editor-in-Chief of Science (2009-2013) and two six-year terms (1993-2005) as the president of the National Academy of Sciences. He was also one of the first three Science Envoys (2009-2011) to the Islamic World appointed by President Obama. During his tenure at the NAS, Alberts was instrumental in developing the landmark National Science Education standards that have been implemented in school systems nationwide. Alberts is also noted as one of the original authors of *The Molecular Biology of the Cell*, a preminent textbook in the field. Dr. Alberts earned a doctorate from Harvard University in 1965.

Prof. Micheal Reiss, External Expert to the Task Force on Science at Universities of the Muslim World

Prof. Michael Reiss is Professor of Science Education at UCL Institute of Education, University College London, Visiting Professor at the Universities of Leeds and York and the Royal Veterinary College, Honorary Fellow of the British Science Association and of the College of Teachers, Docent at the University of Helsinki, Director of the Salters-Nuffield Advanced Biology Project, a Fellow of the Academy of Social Sciences and a Priest in the Church of England. His research and consultancy interests are in science education, bioethics and sex education. He is President of the International Society for Science & Religion International Association for Science and Religion in Schools and writes on the interface of science education and theology. For further information see www.reiss.tc

Prof. Adil Najam, Member of the Task Force

A Pakistani academic and intellectual, Dr. Adil Najam is the founding Dean of Frederick S. Pardee School of Global Studies at Boston University. He is also the former Vice Chancellor of Lahore University of Management Sciences (LUMS) and Director of Center for the Study of Long Range Global Future. Adil Najam is one of the world's leading expert in developing country environmental policy, international environmental negotiations, and politics in South Asia. He was also one of the lead authors of the Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), works for which the IPCC shared the 2007 Nobel Peace Prize with Al Gore. Najam holds two Masters Degrees and a PhD from the Massachusetts Institute of Technology (MIT).

Prof. Mustafa El-Tayeb, Member of the Task Force

Dr. Mustafa El-Tayeb had a long and distinguished career at UNESCO and is currently the President of Foundation University in Sudan. Dr. El Tayeb joined UNESCO in 1981 as a programme specialist in charge of the development of scientific research and higher education in the Arab region. 1986, Dr. El Tayeb assumed the post of the Chief of Section responsible for Arab States and then became responsible for both Arab States and Africa Sections. In 1996 Dr. El Tayeb was appointed Director of the Division of Policy Analysis

& Operations of UNESCO and given the task of building UNESCO's capacity in this area. Since then UNESCO reinstated the programme of science technology and innovation policies. Dr. El-Tayeb has also served as a Founding Member of the Arab Academy of Sciences, a Corresponding Member of the Royal Academy of Overseas Science (Belgium), the Secretary of the UNESCO-EOLSS Joint Committee in Charge of the Encyclopedia of Life Support Systems and the Editor in Chief of the UNESCO Science Report. He holds Masters and PhD in Geophysics from Bordeaux University of France.

Dr. Moneef Zou'bi, Member of the Task Force

Dr. Moneef Zou'bi is the Executive Director of Islamic World Academy of Sciences (IAS), Jordan where he is responsible for managing the premier science academy spanning 57 Islamic countries. Dr. Zou'bi has written extensively on science, technology, and education, and has delivered lectures in more than 25 countries. He has published over 40 papers on science and technology, history of science, and science academies and edited and co-edited 10 books on topics such as higher education, the environment, water resources, as well as transformational technologies.

Dr. Nadia M. Alhasani, Member of the Task Force

Dr. Nadia M. Alhasani is Professor of Engineering and Applied Sciences, Dean of Student Life, and Founding Director of the Women in Science and Engineering Program (WISE) at the Petroleum Institute in Abu Dhabi. She has received numerous awards and fellowships including 2006-7 Research Fellowship of the Aga Khan Program for Islamic Art and Architecture at MIT, 1990-91 Willard A. Oberdick Fellowship in the Building Sciences from the University of Michigan, and Graham Foundation Grant. Alhasani actively lectures and publishes on higher education in the Middle East and women in STEM fields. She holds a Bachelor of Science Degree from Baghdad University, a Masters from MIT, and a PhD from University of Pennsylvania.

Tan Sri Dato Dzulkifli Abdul Razak, Member of the Task Force

Dzulkifli Abdul Razak was formerly the Vice Chancellor of Universiti Sains Malaysia (USM). He is also the 14th President of the International Association of Universities (IAU), a UNESCO-affiliated organization, based in Paris. At the national level, he served as the Chair of the Malaysian Vice-Chancellors' Committee (2006-2011) and Chair of Malaysian Examination Council during the same period. He served as Advisor to the National Higher Education Research Institute (IPPTN), as well as a member of National Higher Education Council. Prior to this, he was the President of Association of Southeast Asia Institutions of Higher Learning (ASAIHL) from 2007-2008.

Prof. Jamal Mimouni, Member of the Task Force

Jamal Mimouni is an Algerian particle astrophysicist and is currently a Professor of Physics at University of Constantine in Algeria. Prof. Mimouni has been an active participant on the debate on science, society and the cultural dimension of the scientific enterprise in the Arab-Muslim world, he is also the President of the Sirius Astronomy Association. He has authored a book entitled 'The Story of the Universe: from Early Conceptions to the Big Bang' – the only one of its kind in Arabic. Prof. Mimouni holds a PhD in Particle Physics (1985) from the University of Pennsylvania.

Dato' Lee Yee Cheong, Member of the Task Force

Dato' Lee Yee Cheong is currently the Chairman of UNESCO International Science Technology and Innovation Centre for South-South Cooperation (ISTIC) and is also Member, National Science and Research Council, Malaysia and Member of the Malaysian Global Science and Innovation Advisory Council, New York. Dato Lee Cheong has been a lifelong supporter and proponent of STEM education and was the Founding Fellow of Academy of Sciences, Malaysia. In addition, Dato Lee Cheong is also the Coordinator of UN Millennium Project Project's Task Force on Science, Technology and Innovation. The Millennium Project has been commissioned by UN Secretary General Kofi Annan to advise him on helping developing nations achieve the Millennium Development Goals by 2015.

Dr. Ameenah Gurib-Fakim, Member of the Task Force

Dr. Ameenah Gurib-Fakim is President of the Republic of Mauritius. She holds the singular honor of being the Woman Scientist to be elected Head of a State. She is a Professor at University of Mauritius and a former Director of Center for Phytotherapy Research (CEPHYR) at University of Mauritius. Dr. Gurib-Fakim has won several awards such as L'Oreal-UNESCO Women in Science Award 2007 and the African Union Award for 'Women in Science' for the Easter African Region in 2009, and Order of the 'Commander of the Star and Key of the Indian Ocean' by the Government of Mauritius in 2008 and the Order of the 'Chevalier de l'Ordre des Palmes Academiques' Government of France 2009. She is the Fellow of the Islamic Academy of Sciences (IAS) and the African Academy of Sciences. She holds a PhD in Chemistry from the University of Exeter, United Kingdom.

Dr. Shoaib H. Zaidi, Invited Contributor

Dr. Shoaib Zaidi is the Professor and Dean of School of Sciences and Engineering at the newly formed Habib University in Karachi, Pakistan. Prior to this, Dr. Zaidi was the Dean of Electrical and Computer Engineering at NED University, Karachi. He has also taught at Ghulam Ishaq Khan Institute of Engineering Sciences and Technology – Pakistan's leading public and private sector engineering universities, respectively. Prior to returning to academia, Dr. Zaidi also spent several years working in the semiconductor industry in the United States. His research and professional interests include higher education, lithography, optical metrology, semiconductor process engineering and control, and semiconductor material analysis. Dr. Zaidi holds a PhD Electrical Engineering from University of New Mexico (1998).

Dr. Athar Osama, Project Director, Task Force on Science at Universities of the Muslim World

Dr. Athar Osama is a science policy adviser and consultant and the founder of the Muslim World Science Initiative and publisher of Muslim-Science.Com. He is also the Founder and Chief Executive of Pakistan Innovation Foundation and the Founding Partner of Technomics International Ltd - a public policy research and consulting firm. Prior to this, Dr. Osama was the Director of Middle East and Asia for Angle Plc. - a UK-based technology commercialization consulting, management, and venture capital firm that specialized innovation programmes, incubators, and research parks in Europe, North America, and the Middle East. Dr. Osama has advised several state and national governments across Asia, Middle East, Europe, and North America and institutions like Dfid, ADB, UN/ITC, The OIC, The Carbon Trust, and The Royal Society, among others. Dr. Osama is the Fellow of the NY-based World Technology Network (WTN) and a Young Global Leader (2013-18) for the Davos-based World Economic Forum (WEF). Dr. Osama did a PhD in public policy from the Pardee RAND Graduate School in Santa Monica, CA and has a Bachelors degree in Aeronautical Engineering from Pakistan Airforce Academy where he won the coveted 'Sword of Honor'

Appendix: Selected Data Tables

GERD as Percentage of GDP ¹

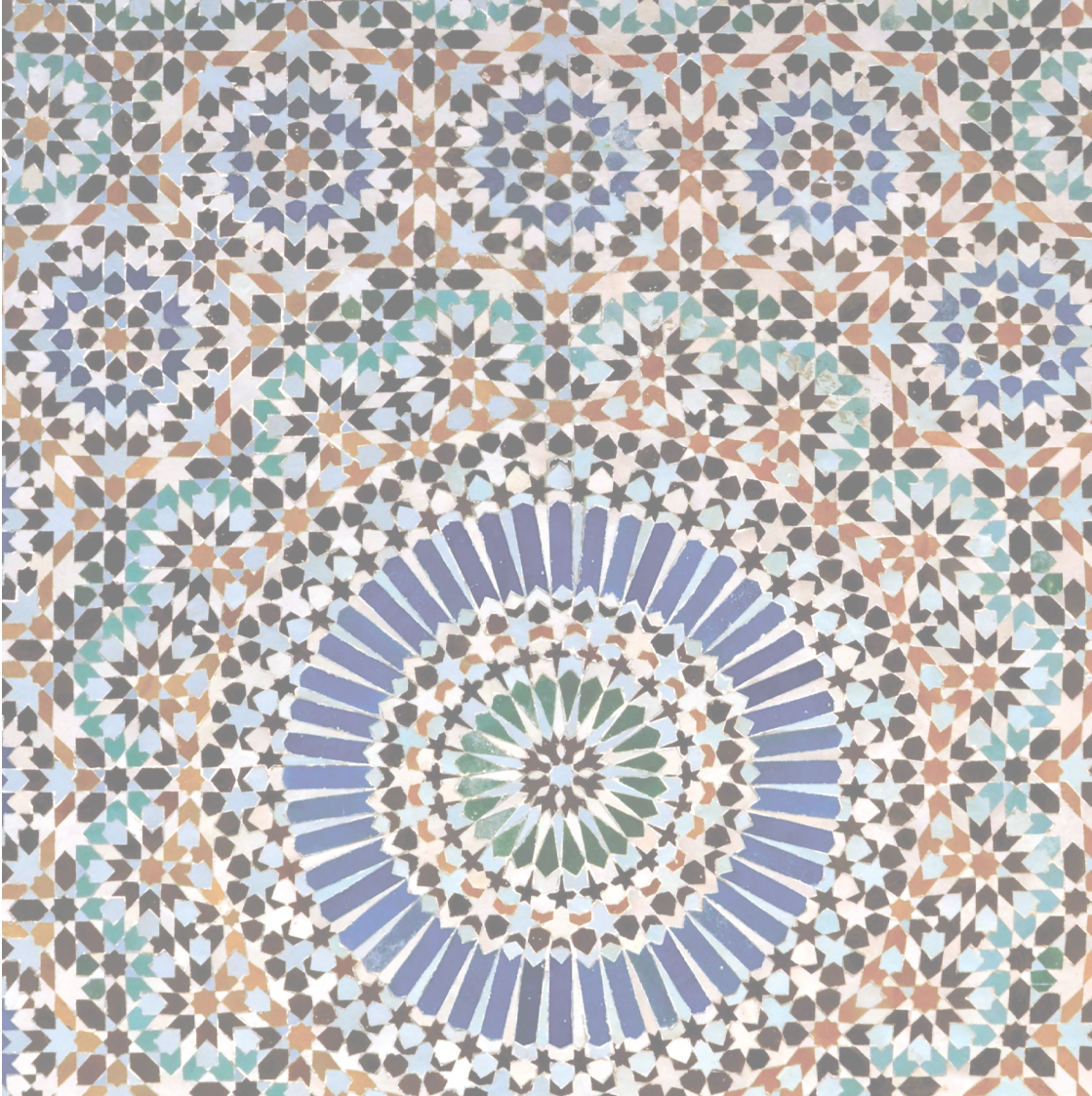
Country	2000	2005	2010-2012
Algeria	0.23	0.07	
Egypt	0.19	0.24	0.42
Indonesia	0.07		0.08
Iran	0.55	0.73	0.75
Iraq			0.04
Jordan	0.34		0.43
Kuwait	0.18	0.10	0.10
Malaysia	0.47	0.60	1.07
Morocco	0.60	0.64	0.73
Pakistan	0.13	0.44	0.40
Saudi Arabia	0.06	0.04	0.07
Senegal			0.54
Tunisia	0.41	0.92	1.10
Turkey	0.48	0.59	0.84
Brazil	1.02	0.97	1.21
Israel	4.17	4.31	3.97
South Africa	0.73	0.90	0.76
Spain	0.91	1.12	1.40

¹ Source: UNESCO Institute of Statistics - http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&popup-customise=true&lang=en

Total R & D personnel per million inhabitants for select countries.²

Country	2000	2005	2010-2012
Algeria		216	
Egypt		~1,000	1,131
Indonesia	270		
Iran	NA	NA	NA
Iraq			544
Jordan	5,171		
Kuwait	378	348	277
Malaysia	430	605	1,785
Morocco		750	1,016
Pakistan	300	337	400
Saudi Arabia	NA	NA	NA
Senegal		280	436
Tunisia	966	1,621	~2,000
Turkey	427	727	1,270
Brazil	762	1,054	1,366
Israel			9,039
South Africa	460	597	573
Spain	2,994	4,028	4,624

² Source: UNESCO Institute of Statistics - http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&popup-customise=true&lang=en



The Muslim World Science Initiative

Email: editor@muslim-science.com

Facebook: [/MuslimscienceCom](https://www.facebook.com/MuslimscienceCom)

Twitter: [@MuslimScience](https://twitter.com/MuslimScience)

Web: <http://www.muslim-science.com>

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