STEPHANE COMPOINT/GRAZIA NERI

FEATURE

Joining the Fast Lane

Ismail Serageldin

The values of science must be integrated into the fabric of our societies.

In their fight to raise living standards and realize their economic and social potential in the coming decades, there is one thing developing countries cannot do without: homegrown capacity for scientific research and technological know-how. Increasingly, a nation's wealth will depend on the knowledge it accrues and how it applies it, rather than the resources it controls. The "haves" and the "have-nots" will be synonymous with the "knows" and the "know-nots".

The gap between the advanced industrialised countries and those whose populations are mostly poor is still growing. Notwithstanding the enormous advances of China and India, and the significant progress made by Brazil, Mexico and a handful of other developing countries, many in the developing world are being left behind, especially in Africa (except for South Africa) and in the Muslim world generally. Yet, with prompt and determined action these countries can turn things around. That is not an unrealistic goal: Singapore, South Korea, Taiwan and others have already achieved it. Even if they don't attain such spectacular results, at least they could close the gap with the developed nations to a significant degree. How should they go about this?

The InterAcademy Council (IAC), an international advisory group linking the world's science academies, has recently produced a report on this subject, put together by a panel that I had the honour to co-chair. It recommends paying special attention to five areas: national science policy, teaching reform, the establishment of centres of excellence, the impact of private sector and the financing of research in developing countries. In each of these areas, the focus should be on building up a nation's ability to conduct scientific research and reap the benefits of the resulting technologies. For developing countries, it is the only path to progress.

The first step is to adopt a coherent national framework to promote science and technology, developed by the government in consultation with the country's scientists. The strategy should use the experiences of other countries and should spell out a government's commitment to such things as funding, standards of excellence, innovation and regional and global collaborations. It is also important to get the media on board. It is no longer realistic to expect support for science without the engagement of the public. Winning public support can be a challenge: there is a strong anti-science bias in many societies, perpetrated by religious zealots, romantic-minded non-governmental organizations and those inclined to believe quackery.

National academies of science, engineering, agriculture and medicine can help by improving the quality of public discourse, as well as the quality of national science and technology programs. National academies are member-based autonomous institutions independent of government and motivated by their commitment to scientific or engineering excellence. As such they are extremely important for upholding the quality of a country's scientific and technological endeavours, for guiding national policies on science and technology, and for maintaining dialogue with other countries.

In the absence of formal academies, some governments might have to rely on a group of the country's leading scientists and intellectuals to act as an ad-hoc committee. Such a committee could also draw on international expertise, including some of its own expatriate scientists. International academic bodies can help considerably both in the development of a country's science policy and in the building of its institutions – organizations such as TWAS, the academy of sciences for the developing world, the International Council for Science (ICSU) and the InterAcademy Panel (IAP). In particular, they can help establish the necessary high standards and effective organizational structures.

Once a national science strategy is up and running, then science can start to inform public decision-making – a crucial role in developing economies. Many public policy issues can only be properly resolved with in-depth knowledge and science-based analysis – questions such as which form of energy to use, how to increase agricultural production, how to protect the environment and improve public health. It is essential that national academies actively participate in national and international debates on these and other issues, not only to inform the debate but also to make the voice of science heard.

In addition, it is important to promote the "values of science" that effectively allow the pursuit of research to flourish. These include: rationality, creativity, the search for truth, adherence to codes of behavior and a certain constructive subversiveness. Science requires freedom: freedom to enquire, to challenge, to think, to imagine the unimagined. It requires tolerant engagement with the contrarian view, accepting to arbitrate disputes by the rules of evidence and rationality. The content of the scientific work is what is discussed, not the person who produced it, regardless of the color of their skin or the god they choose to worship or the ethnic group they were born into or their gender. These are societal values worth defending, not just to promote the pursuit of science, but to have a better and more humane society.

After policy, the second key task to building a national foundation in science and technology is to improve the quality of teaching, especially in science and mathematics, from pre-school through to graduate studies. This is less about building a curriculum and training teachers, important as these are, and more about communicating to children the enormous adventure of discovery inherent in the scientific enterprise. It is about teaching them to appreciate the elegance and beauty of mathematics, and helping those who are interested in the subject to realize their potential. It is about engaging people with the quest for knowledge.

One mistake that many developing nations have made when trying to improve education is to focus on increasing the length of time students spend in education while failing to address the quality of learning. Governments tend to believe that the longer someone spends studying, the more they will ultimately contribute to the national drive for economic development. However, recent long-term studies by the World Bank and others show that increasing the number of years in education has only a limited effect on promoting economic growth, while improving the quality of the education has a markedly positive effect.

Another educational challenge is to reform universities – a vital task. The university is an engine of modernization and change in any society and an enormous force for progress. Its social and political roles are as important as its scientific and technological ones. Many universities in the developing world today are still relying on rote learning of fixed curricula and following an apprenticeship model in their graduate studies. Reform is badly needed. Greater recognition must be given to the possibilities of self-learning and guided learning (such as distance-learning) and not just formal instruction based on student-teacher interaction in classrooms.

Governments in developing countries will need to address the "brain drain" of their talented youths to more promising futures and lucrative careers in the advanced industrialized countries. They will also have to find ways to attract larger numbers of talented persons, including women and minorities, into the sciences, and then try to retain them in these fields. They can organize effective joint training with the universities in the advanced countries where the topics of research would be more applicable to developing country needs, and where part of the work could be done in the home country. In addition, the returning graduate students should be supported by special grants and the possibilities of working in better laboratories. However, some emigration is unavoidable as an aging North will draw on the younger South to staff its hospitals and its institutions. So developing country governments have to turn "brain drain" to "brain gain" by building constructive links with the expatriate scientists, doctors and engineers that are likely to lead to collaborative research, itself an important factor in building a strong scientific base for R&D in the developing countries.

For successful development, countries need more than good schools and universities: they need "centres of excellence", institutions dedicated to cutting-edge research and training in science, medicine, agriculture and engineering.

Centres of excellence are the key to innovation; their importance cannot be overestimated. Every developing country will need one to help it grow its capacity in science and technology. The centres will need to be autonomous, with capable leadership and sustainable financial support, and will need to have focused research agendas. Each new research project should be funded competitively, decided by expert review, and evaluated on both its technical merits and its potential benefits to society. The review panels should ideally include appropriate experts from other nations.

An important step is the creation of so-called "virtual networks of excellence" (VNEs), which link geographically distant research groups and institutes across the nation and the developing world via the internet, allowing them to work collaboratively, nurture scientific and engineering talent, expand by pooling available academic resources and share expertise. Such VNEs, however, require at least one real "bricks and mortar" institute or centre of excellence to act as as an anchor for the network. Successful examples of VNEs are the research networks created in several countries by

VIEWPOINT | Mario Molina

Air pollution is a global problem with local solutions

Air pollution is a serious problem in cities across the developing world. There are, however, examples of cities that have taken advantage of existing technologies to partially mitigate the problem. With 20 million people, Mexico City is the world's second largest city after Tokyo. It is also situated in a valley where polluted air tends to become trapped. As a result, it has long suffered from pollution problems that have adversely affected public health. Mexico City's health problems became so acute in the 1990s that they prompted the government to take action. Emission standards were set and vehicles were required to undergo inspections twice a year. In addition, new vehicles had to be equipped with catalytic converters that significantly reduce noxious tail-pipe emissions. Leaded fuel damages catalytic converters; so, the introduction of catalytic converters also led to the widespread use of lead-free gasoline. Motor vehicles produce three-quarters of Mexico City's air pollution. As a result, the measures taken have created noticeable improvements in air quality. In China, where large cities also suffer from excessive air pollution, the situation is different. A larger portion of the air pollution is due to emissions from power plants and industrial facilities. Technologies also exist to curb emissions from these sources; however, power plants and industrial facilities drive economic growth in China, where, for example, one new coal-fired steam plant is being added to the electric grid every 7–10 days. The Chinese government made an enormous effort to improve air quality in Beijing for the Olympics. We can only hope that this effort will spread to other cities as well.

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the Millennium Science Initiative with the support of the World Bank.

The private sector is increasingly driving global R&D efforts, not just by the size of its financing, but also by the nature of the activities it chooses to finance, and the manner in which it makes its findings available to the international community. No government can afford to ignore the role of the private sector in research and development today. Globally, private funding of scientific research has gone up from around 30% some twenty years ago to about 70% today. That enormous funding is driven by a powerful intellectual property rights regime, and is naturally focused on areas where the private sector can make returns on its investment. However, in the poorer developing countries, the private sector plays a marginal role in funding research. This dominance by the private sector in industrialized countries raises many questions for developing countries such as Egypt, which still rely overwhelmingly on public funding for research and development (R&D). Increasingly, they will find that the administrative and financial burden of coping with an ever-more intrusive patenting system inhibits research, since many of the raw materials necessary to conduct research are covered by restricted patents. Imaginative proposals are needed to find ways of promoting R&D that benefit both developing and industrialised nations.

A major issue will be the capacity of governments to work with the international private sector, where multinationals have enormous capabilities that could be brought to bear on the problems of developing countries. But the issue goes beyond finance. It involves the nature of the science being supported by the private sector, and the nature of the problems that they choose to address. The private sector will not fund public goods and thus public goods research must be funded by the public. Therefore, a part of any strategy for science and technology must be a better understanding of this public/private interface — how to maximize the complementarities and minimize the duplications. In developing countries, where the private sector is still weak, leading parastatals that enjoy managerial autonomy, or mixed ownership companies, can play an additional role. Public-private partnerships must be nurtured by the governments as part of the overall strategy for science and technology.

How should all this be financed? The crucial issue with funding science and technology development is not so much the amount of money provided – though, of course, that is important – as how it is directed. Funds need to be focused on those research areas prioritised by the government's science strategy, and allocated by a competitive grant system based on merit. Those are the two most important conditions for ensuring that any available money is used effectively.

There are several ways of funding R&D besides the conventional ones. One of them is national sector funds. Brazil successfully redirected corporate taxes for conducting research in areas of economic interest to the corporations being taxed, yet with funding decisions resting with scientists familiar with the sector. The academic community, the government and industry should work closely together to manage national sector funds, part of which should be used to support both basic science and infrastructure needs.

Another way of funding science and technology research is to direct money through regional networks, in which neighboring nations come together to work on issues of mutual concern. TWAS is promoting collaboration between developing nations, and there are already fellowships in place allowing academics from the least developed countries to work in Brazil, India and China. Though small, these programmes are important because they hold the seeds for future growth in collaboration between the countries involved. Regional networks could also act as a forum for cooperation with developed nations.

Two other possible methods of finance are through a global "institutional" fund, which would provide funding for 5, 10 or even 20 years, to regional or national centres of excellence, allowing the centres to promote the values of science and engineering and create an environment in which high-quality research can flourish; and a global "programme" fund to support specific research programmes, with international referees deciding which projects were most worthy of funding. A prime example of a global programme fund is the Gates Foundation Grand Challenges programme to improve vaccines.

Finally, it is worth mentioning the value to developing countries of the new digital libraries. These libraries can bring knowledge to virtually everyone, everywhere. Scientists and technologists in developing countries have limited access to recent research findings, which are mostly found in subscription journals; to reference materials, found mostly in libraries elsewhere; and to databases, some of which are proprietary. Digital libraries accessible over the internet offer a way forward, and it is essential that governments in developing countries help their research and learning institutions to take advantage of them by providing the necessary communications infrastructure. *Bibliotheca Alexandrina*, the new Library of Alexandria, is making great efforts in this direction, but it is a small part of what must become a regional and global enterprise.

Developing countries are some way behind on the path to economic well-being, but they have every hope of achieving it. It is up to us and to future generations to ensure that the values of science are integrated into the fabric of our societies. Laying this foundation is the best way of guaranteeing better lives for all. Perhaps it is the only way. ■

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