

**Strengthening Natural Science Research and Education in African Universities**  
*Lessons from Eurasia*

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## **Introduction**

Scientists and engineers in Africa are in the best position to understand and address local and regional challenges, but only if they can strengthen their indigenous problem-solving and technology-generating capacity. Most Africans see improving higher education in Africa, in particular in the natural sciences and mathematics, is therefore crucial for improving the region's economic and social conditions. Strengthening the capacity of scientific research in African universities will help countries tap into the resources of the global research and education community to solve immediate and long range development problems. It will also prepare the human capital that is a prerequisite for attracting international investment. This paper explores ways to build strong goal-oriented natural science research into African higher education and to link young African scientists to world science in a way that encourages them to utilize their talents in their home countries and regions.

Though well-endowed with natural and human resources, Africa captures only a fraction of the price of global products incorporating these resources, since the majority of exports are raw materials. It also faces public health and environmental crises which sap its own finances and which require it to allocate an inordinate amount of international assistance into addressing today's crises instead of building the infrastructure for tomorrow. The youth population in Sub-Saharan Africa is more than four times its 1950 level and this trend is projected to continue for a foreseeable future.<sup>1</sup> However, this demographically young population lacks sufficient opportunities for both educational advancement and for full utilization of its talents. This paper describes a strategy for development of scientific research in higher education that promises to initiate a process that will provide Africa the indigenous and internationally engaged experts to solve local problems.

Sub-Saharan Africa faces many developmental challenges and is ranked the lowest of the world's regions in most development measures. The continent is failing to attain the Millennium Development Goals.<sup>2</sup> The failure to meet these development goals is due to the countries' inability to effectively utilize their resources and implement policies that encourage development. In most cases, institutions are not equipped and structured in a way to address the challenges related to health, education or poverty. Only with strong scientific research capabilities can a nation address its developmental challenges.

Enhancing university research, in addition to improving the quality of scientists educated in African universities, will also stem the problem of brain drain. Improved material conditions for researchers, modernized equipment, and access to information on global scientific developments in their field will encourage experts to stay in their home countries, utilizing their talents and expertise in Africa. As relevant opportunities emerge for conducting scientific research in their home countries, scientists that might otherwise have emigrated will choose to remain, while

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<sup>1</sup> World Bank (2008) "Accelerating Catch-up: Tertiary Education for Growth in Sub-Saharan Africa", Directions in Development, Human Development.

<sup>2</sup> United Nations (2008). The Millennium Development Goals Report.

those who have already left – many of whom are underemployed – may be lured back to contribute to the development of their homelands.

The central argument of this paper is the importance of integrating scientific research into higher education in the sciences. This argument is illustrated by a case study largely drawn from Eurasia. Thus, the paper explores whether a successful Basic Research in Higher Education program in Eurasia can be adapted to African countries.

### **Science-led Development**

*Sub-Saharan Africa contributes about 2.3 percent of world gross domestic product but is responsible for only 0.4 percent of global expenditure in research and development. With 13.4 percent of the world's population, the continent is home to only 1.1 percent of the world's scientific researchers. This is about one scientist or engineer per 10,000 people, compared with 20-50 in industrial nations. Over the years, the science and technology gap between Africa and the rest of the world has grown.... [s]ome economists feel that this widening gap is partly responsible for the continent's underdevelopment... [As Rwandan president Paul Kagame stated,] the question now facing many African countries is ...where are we headed, and what needs to be done to give science and technology their due weight in our development process?*<sup>3</sup>

Economic thinking about growth and development has evolved in the past decades. “Post-war growth theory stressed the need to accumulate factors of production—capital, and unskilled and skilled labor—and to increase the productivity with which these factors are used”<sup>4</sup>. To succeed in knowledge based economy, a country should be able to adopt policies to strengthen its science and technology capabilities. Most importantly, young graduates in the natural sciences must be capable both to address local problems and to compete internationally.

In order to solve technological challenges locally, a country or region needs several things:

1. A cadre of scientists and engineers who understand local problems and are trained to address them,
2. The capability to carry out scientific research and generate technological solutions to problems,
3. Ties to the developed world's scientific expertise to tap into prior advances, capabilities, and ideas.

Fortunately, in recent years there appears to be hope for policy changes in most African countries. Since the start of the new millennium, economic growth in the region, measured by gross domestic product, has increased from 2.0 percent in the 1990s to 6.0 percent between 2002 and 2007.<sup>5</sup> This change is mainly due to increased macroeconomic stability. During the same

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<sup>3</sup> Mutume Gumisai (2007) Africa Aims for a Scientific Revolution, Africa Renewal.

<sup>4</sup> Simon Johnson, Jonathan D. Ostry, and Arvind Subramanian (2007) “The Prospects for Sustained Growth in Africa: Benchmarking the Constraints”, IMF Working Paper.

<sup>5</sup> World Bank (2008) “Accelerating Catch-up: Tertiary Education for Growth in Sub-Saharan Africa”, Directions in Development, Human Development.

period the importance of higher education has increased. Development experts and international donors have focused on primary and secondary education for decades, and certainly the problem of early education remains acute in many places in Africa. But higher education and research has been identified as a critical component to development<sup>6</sup> And the time is right to emphasize scientific training at the tertiary level. The African Development Bank has observed that “in a knowledge economy, higher education can help economies gain ground on more technologically advanced societies, as graduates are likely to be more aware of and better able to use new technologies.”<sup>7</sup> One way of meeting this challenge is to integrate scientific research into traditional universities, which aids in training a skilled workforce while reducing brain drain.

As brain drain has hindered many African universities from building strong master’s and doctoral programs, “nurturing good scientists through merit based selection systems ...to create and maintain strong, quality institutions must become one of the highest priorities of [African] governments” (IAC : 20).<sup>8</sup>

The challenge is how to successfully create research-intensive institutions of higher learning. Fortunately, various programs have already been implemented throughout the world to address this challenge. The following section gives a detailed discussion of one of the successful programs linking basic research to the education of scientists in traditional universities.

### **Case Study: Basic Research and Higher Education in Russia**

After the end of the Soviet era there was widespread concern in Russia and abroad about the brain drain of researchers from Russia, brought about by the collapse of state financing for science. In the early 1990s various international programs tried to stem these developments, but thousands of experienced scientists and engineers emigrated from Russia to Europe, the United States, Israel and elsewhere. Others remained in Russia but left science, while in parallel, the flow of young people entering university to pursue science careers slowed to a trickle. Science was no longer the well-paid, prestigious career it had been in Soviet times, and students were not routinely introduced to scientific research in the course of their university education. This was a result of the sharp division between higher education in universities and basic research, which was the province of the Russian Academy of Sciences. The Basic Research and Higher Education program (BRHE) sought to overcome that division and reintegrate research into the education of young Russian scientists.

BRHE began in 1997 with a partnership between the US Civilian Research & Development Foundation (CRDF) and the Russian Federation Ministry of Education, with US-side funding from the John D. and Catherine T. MacArthur Foundation and Carnegie Corporation of New York. Guided by a bilateral group of interested experts, Research and Education Centers (RECs) were designed and established to:

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<sup>6</sup> David Bloom, David Canning, and Kevin Chan (2005) “Higher Education and Economic Development in Africa, Harvard University”.

<sup>7</sup> African Development Bank Group (2007) “Strategy for Higher Education, Science and Technology, Operations Policies and Compliance Department”.

<sup>8</sup> InterAcademy Council Report (2004) “Realizing the promise and potential of African agriculture: science and technology strategies for improving agricultural productivity and food security in Africa”.

- stimulate innovation and excellence in research and research-oriented education;
- provide up-to-date equipment for research and education;
- promote linkages in research and education with other universities and research institutes, within and outside Russia; and
- rejuvenate universities by providing opportunities for promising young scientists.

A pilot center at Nizhny Novgorod was followed by nineteen more RECs chosen in five peer-reviewed competitions sponsored by CRDF and the Russian Ministry of Education. Grant funding has been provided by both sides in varying proportions, and all grant decisions were reached via bilateral consensus.

### ***Gaining local support and local contribution***

The initial involvement of a number of key Russian academics, the design of a peer-based governance structure and the continuity of the key players on the U.S. and Russian sides created the trust required for true mutual commitment.

As the Russian economy has gained strength, the BRHE program has now clearly been adopted and replicated on a larger scale by the Russian Ministry of Education and Science, which is an encouraging sign that the program will be sustained following the end of U.S. funding. Moreover, within even the first three years, RECs report a significant increase in the amount of external non-state research funding that they are able to attract, providing yet another path toward sustainability.

### ***Collaborative possibilities and local support***

The BRHE program represents a major investment from the U.S. private philanthropic sector and Russian funding partners which include the Ministry of Education and Science of the Russian Federation, regional and local governments, and universities. CRDF has functioned as the implementation agency as well as the source of many of the ideas that made the program operational. The governance process of the BRHE program has been based, from the outset, on a true and exemplary U.S.-Russian partnership between CRDF and the Russian Ministry of Education and Science and several independent advisors on each side.

The 20 RECs of the BRHE program are innovative models and ‘centers of excellence’ in their fields. The program is helping to integrate teaching and research, promote the development of a new type of Research University in Russia, and train a new generation of scientists and scholars to take their place in Russian higher education.

### ***Economic impact - New technologies***

In one of the world’s largest countries, it is difficult to assess the macroeconomic effect of a relatively small higher education program. However, some anecdotal evidence may serve to indicate that the BRHE program is a success both as a model for educational development and as a stimulus to innovation and entrepreneurship.

After the structural adjustment crisis during the 1990s and the financial collapse in 1998, the entire social-cultural system (including education and research) in Russia was deeply affected and confronted with the need to construct new social, economic and political foundations. The

BRHE program with its structural programmatic change agenda was established at the right time. Directly after the 1998 crisis, it could offer its services and act as a trigger to modernize the link between higher education and research and development.

Since 2002, CRDF has teamed with OECD to provide annual workshops for all RECs on technology commercialization topics of increasing complexity. CRDF and the Russian Ministry of Science have also made competitively-awarded grants to establish Technology Transfer Offices in eight of the participating universities. These Technology Transfer Offices have assisted in training scientists in the RECs and their host universities about intellectual property protection, licensing, and in many cases have assisted scientists to form spinoff companies based on inventions stemming from their research. One office, in its first two years of operation, assisted the creation of 12 new small businesses. It also helped university scientists patent 169 inventions and actively promoted 31 of them, concluding two licensing arrangements.<sup>9</sup>

### **Lessons from Eurasia**

The BRHE program has been tested and found effective in catalyzing a transformation of the higher education landscape within Russia. From an atmosphere of widespread skepticism, particularly on the part of entrenched research organizations, the Russian Ministry of Education and the Russian Academy of Sciences have both now embraced the desirability of building Research Universities as the surest path to a robust technology sector. Validating this model further, the Ministry has held multimillion-ruble competitions for additional centers modeled on the BRHE RECs.

Indeed, the success of the program in Russia led CRDF to replicate the program on a smaller scale in five additional countries. Each program has been tailored to the needs and preferences of the host country. In Ukraine, for example, the centers deliberately address urgent national needs (mining safety and energy efficiency), whereas the Russian centers generally focus on basic research.

The transformation described in this paper required a long-term commitment from national and local governments in Russia, as well as external funders. Western funders and implementing organizations like CRDF can play a crucial role in articulating a vision of opportunities, initiating transformation, and influencing it in positive ways. Partnership between a host government and an international implementing organization, fueled by cost-sharing from both sides, creates a cooperative atmosphere that lays the groundwork for successful implementation.

CRDF has learned several lessons through ten years of implementing these programs. A key lesson is that selection of the universities to host the RECs is best done through open competition. A bilateral selection process incorporating peer review on both sides ensures that the grant recipients are the most qualified and most likely to succeed. Even for the unsuccessful applicants, a transparent process gives assurance that each application was carefully and fairly reviewed, and valuable experience in proposal-writing.

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<sup>9</sup> End-of-Grant Progress Report for REC Research and Education Center “Physics and Chemistry of High-Energy Systems,” Tomsk State University, Public Summary 2005.

## **From Eurasia to Africa?**

Indigenous scientific capacity in Africa has improved with the wealth of scientific and technological advancement and African countries do not need to build from scratch. The challenge is to expand on existing knowledge and adapt it to local needs. Recent developed and emerging economies like Japan, South Korea, Singapore, Ireland, Brazil, China, India, Malaysia and Thailand followed this approach. Their success was highly dependent on building basic infrastructure and investing in higher education in addition to private enterprise and tapping the global market.<sup>10</sup>

Technological advancement and the institutional framework to support higher education must be central in the development policies of African countries to support long-term growth; integrating research in higher education and adoption of international best-practices are necessary steps to achieve these goals. Specifically, we recommend a program that will build science and technology capabilities to address local and regional challenges, devote resources to young scholars enabling them to create and promote innovative activities with improved institutions, and incorporate science and technology advances to meet the Millennium Development Goals.

Economic growth can mostly be improved by a science and technology policy. Sustainable development in Africa requires enhanced science and technology capacity. However, these policies can only play a major role in economic growth and development “when integrity of the whole enterprise-research institutions, universities, publications research priorities and emphasis and the education of creative scientists, as well as those active in science is preserved.”<sup>11</sup>

Africa faces a challenge in some ways similar to that faced by Russia in the 1990’s. As a result of the collapse of scientific funding and extensive brain drain following the breakup of the Soviet Union, Russia experienced a demographic gap in its scientific workforce that to some extent still persists. Senior scientists could not afford to retire, and hundreds of younger scientists either left Russia or left science. The average age of university professors and academy researchers rose as the number of young people entering science fell. Training the next generation became a challenge requiring a new approach to science education, a need that BRHE filled.

Though the reasons for the demographic difficulty are different, the problem is the same in Africa: the number of professors in Africa is in decline.<sup>12</sup> In places where there is some improvement in numbers; professors are not engaged in research and are ill equipped to transfer their knowledge to young scholars. In Africa, the problem is becoming more critical more quickly as large number of professors are retiring.

Africa needs a way to significantly increase the number of young scientists and provide a career path for them to remain in science and in Africa. As demonstrated in Russia, a program of integrating research with higher education, adapted to each country’s specific needs, can enhance the scientific capacity of African countries in ways described below.

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<sup>10</sup> Juma Calustous (2008) “Learn to Earn”, Nature.

<sup>11</sup> Bilsel Ayhan and Oral Ozay (1995), “Role of Education, Science and Technology in Developing Countries”, ASEE/IEEE Conf.: Frontiers in Education.

<sup>12</sup> Megan Lindow (2009) “Africa’s New Crisis: a Dearth of Professors”, The Chronicle of Higher Education.

### *Integrating research in universities*

The BRHE program in Russia has successfully integrated research in traditional universities. This was done by promoting the development of a new type of Research University in Russia. Research was not part of most Russian universities but this situation has drastically improved in the past decade. African universities have the lowest academic research output in the world requiring serious attention. Integrating genuine research opportunities into higher education develops the crucial competencies of critical analytical skills and creative initiatives, and nurtures a self-sustaining passion for scientific careers among graduates.

### *Empowering the next generation and slowing brain drain*

BRHE has on a limited scale attracted young scientists back to Russia after emigrating for better opportunities abroad. Enhanced research capabilities can help stem and has the potential to reverse brain drain, keeping locally-trained scientists in place to augment the technologically-skilled workforce and address local challenges.

### *Increasing scientific publications*

The BRHE program in Russia has provided training for early-career scientists in proposal writing and making scientific presentations. Additionally, grantees have highly benefited from English language intensive trainings. English is the primary international language in today's science, this training has allowed grantees to interact with foreign colleagues and improve their written and oral scientific presentations at international conferences. As English is a second language in most African countries, a similar training can have a significant impact in African countries.

### *Enhancing international scientific research collaboration*

BRHE emphasized the importance of establishing collaborative relationships both within Russia and internationally. A robust program of collaboration, potentially including exchange of lecturers and students, can invigorate a research program, benefitting both partners. Strong support for international collaboration should be a prominent feature in a program to address global challenges.

## **Conclusion**

The research universities of North America are the most successful research system in the world. Programs to establish and support Research and Education Centers in universities have proven effective at revitalizing the training of young scientists, which is a necessary step in building an economically robust knowledge-based society.

The U.S. Civilian Research & Development Foundation (CRDF - a U.S. nonprofit "do-tank") has worked for over a decade in partnership with local governments to strengthen existing scientific institutions in twelve countries<sup>13</sup> and improve the distribution of existing resources for science. CRDF's experience shows that the development of university-based centers offering basic and applied research capabilities integrated with university education significantly

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<sup>13</sup> Armenia, Azerbaijan, Georgia, Iraq, Kazakhstan, Kyrgyzstan, Moldova, Qatar, Russia, Saudi Arabia, Ukraine, Uzbekistan

increases the involvement of young scientists in research and contributes to a slowing of brain drain.

CRDF recommends a proven model which emphasizes the development of research capabilities integrated with university education to improve the training of young scientists. The model requires international partnership, but more importantly, it requires the local governments' commitment of resources and policies to enhancing science education at the university level.

Technological advancement and the institutional framework must be central in the development policies of African countries for long-term growth. Integrating natural science research in higher education and adoption of international best-practices are necessary steps to achieve these goals. Specifically, we recommend a program that will build science and technology capabilities to address local and regional challenges, devote resources to young scholars enabling them to create and promote innovative activities with improved institutions, and incorporate science and technology advances to meet Millennium Development Goals.

The BRHE model can be adapted to countries in Africa willing to devote some of their own resources to improve the training of young scientists. Through international collaboration it is possible to reduce the disparities between scientifically stronger nations and African countries. The time is right for African countries to establish university research and education centers that can serve as bases for sustainable economic development

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