Advancing science in Africa

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The African Institute of Mathematical Sciences offers a successful template for other disciplines to teach science in Africa.

A great challenge for the scientific community, says physics Nobel laureate David Gross, is to connect Africa with the rest of the international scientific world. Here, we report on a remarkably effective initiative that meets this challenge: the African Institute of Mathematical Sciences (AIMS)[1]. In particular, we argue for a replication of AIMS' impressive success in the fields of physical and materials science. As Gross says, AIMS' model for building scientific capacity offers a particularly innovative and creative approach to advancing scientific talent in Africa.

AIMS is situated at the oceanfront of Muizenberg, in the vicinity of Cape Town, South Africa (Fig. 1). The institute opened its doors four years ago as a partnership between the universities of Oxford, Cambridge, Paris-Sud XI and the South African universities of Cape Town, Stellenbosch and the Western Cape. The institute offers a nine-month post-graduate course in applied mathematics to a carefully selected group of students from across Africa. The Faculty of Mathematics at Cambridge and the Division of Physical Sciences at Oxford are both actively involved. Since 2003, 160 students have successfully completed the course. For the academic year 2007/8, a group of 52 students — more than a third of which are women — from 20 different African countries have enrolled.

The goal of the institute is to enhance the students' mathematical competences and simultaneously provide them with an overview of cutting-edge science. The course is divided into three phases. Firstly there is a 'skills' phase in which topics such as the art of approximation, numerical computation and statistics are taught. This is followed by a 'review' phase in which specialists introduce students to cutting-edge topics in mathematics-related sciences.

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Figure 1 A view of the African Institute of Mathematical Sciences.

The spectrum of topics is extremely broad and includes everything from quantum mechanics to bioinformatics, and from fluid mechanics to the Black–Scholes theory used to estimate prices of derivatives on the stock market. Each topic is presented in an intensive three-week module. Finally, students undertake research projects with researchers at local universities, and summarize their results in essays.

What sets the institute apart, says Fritz Hahne, director of AIMS and former Dean of Science at the University of Stellenbosch, is a focus on excellence that is geared towards the needs of Africa. Most of the 700 universities in Africa have undergone decades of decline and neglect, and desperately need a new generation of faculty and researchers both to raise educational standards and to connect Africa to the international scientific community. Quality of students is one of the cornerstones on which the institute is built, says Hahne. Prospective AIMS students must have a record of academic excellence. The number of applications is an order of magnitude larger than the number of available positions and selecting the best and brightest, the director says, is one of his most difficult tasks. But it is vital: the best learners can take most advantage of what AIMS has to offer.

Focus on mathematics, says Hahne, is another cornerstone. Being the idiom of the sciences, mathematics encourages interdisciplinarity. Thus AIMS can bridge the gap between broad graduate and highly specialized post-graduate studies. Another advantage of the universality of mathematics is that it cuts through cultural barriers that can run deep in Africa, says the director. As English is not the native language of the students, mathematics is the *lingua franca*.

In teaching style, Hahne says, AIMS in a sense went back to the principles of a

medieval university. Students and lecturers live under the same roof, in a building that houses a lecture hall, a library, computer facilities as well as a cafeteria. Thus, over time a tightly knit academic community begins to form with fondness for science as its binding element.

The group of lecturers is very diverse and comes from universities both in and outside Africa — anyone can propose to teach a course via the website of AIMS (ref. 2). It is our own experience as a former lecturer and a tutor of the institute, respectively, that there are significant differences between teaching a course at AIMS and at a regular European or American University. As John Cardy, who holds the Chair of Theoretical Physics at Oxford University, says, a lecturer at AIMS should teach skills that students can use regardless of their field of study. For example, in his three-weeks course on phase transitions that he gave in 2006, the emphasis was on the mathematical concepts that are important beyond the narrow academic area of statistical mechanics.

As a lecturer one also immediately senses another difference: the average student at AIMS is far more motivated than his or her counterpart at a university in the West. Given the deplorable circumstances in many African universities, a stay at AIMS is a unique opportunity to boost the students' scientific careers, making them determined to take everything out of it. This makes lecturing and living in the institute an intense experience. It is very satisfying to see how AIMS students make enormous progress in a course of just three weeks. John Cardy echoes our own sentiments and experience when he says that teaching at AIMS is one of the most rewarding experiences a science lecturer can have.

On the practical side, it is remarkable that the institute runs on a yearly budget of only about US$800,000. Even if all students receive full bursaries, the cost per student is less than a quarter of that at a Western university. This makes AIMS a very cost-effective operation. Nevertheless, fundraising is a constant headache and the institute continues to rely on short-term grants from a wide range of charitable organizations and individuals.

For the next three years, the South African government has agreed to support the institute's running costs but funding for student bursaries, at around $10,000 per student, is still being actively sought. The Ford Foundation[3], the UK's Institute of Physics, and Arcadia[4], a UK trust, are among the contributors so far. Arcadia, for instance, recently granted bursaries for 15 female graduates per annum for the next three years. Barry Supple of Arcadia says that the main reason for their support is AIMS' emphasis on intellectual development in a pan-African setting. As mathematics is applicable to a range of issues, the skills of mathematical modelling and the ability of quantitative predictions can be used widely. Moreover, says Supple, there is an enormous leverage that comes from educating those who can drive socio–economic change and make a difference in the world around them. This resonates well with AIMS' philosophy of teaching the teachers.

After graduation almost all AIMS students continue their career in academia, the vast majority in Africa but a few at leading European and American institutions. Although this is beneficial for the individuals the emigration of graduates contributes to a skills shortage in Africa: 90% of the African mathematics students that earn a PhD outside Africa do not come back.

The brain drain from Africa is a terrible problem, says Neil Turok, one of the architects of the AIMS project and chair of its governing body. Turok is the son of anti-apartheid activists. He grew up in exile and now holds the Chair of Mathematical Physics at Cambridge University. The prime reason for locating the institute in Africa and having a pan-African student body was to offer education in a strongly African environment, encouraging a commitment to the continent. At the same time, a broad spectrum of courses means that students are stimulated to identify and pursue innovative fields in which working in Africa can actually bring them a competitive advantage. A good example is epidemiological modelling, for example of AIDS/HIV. Through a partnership with the South African Center for Epidemiological Modelling and Analysis, some of the strongest AIMS graduates are currently working in this field. The establishment of new mathematics research centres might offer another appealing perspective for the new generation of scientists. Currently one is being planned in a building across the street from AIMS, with the support of Arcadia. A post-doc and long-term academic visitor programme is envisioned for it. The aspiration is that research centres like these can grow into a basis for mathematical sciences in Africa.

Another current initiative that AIMS is helping to coordinate is the African Mathematical Institutes Network (AMI-Net), which seeks to establish institutes similar to AIMS in other African countries. Funding for a preliminary study has been provided by the Vodafone Foundation and other funders, through the New Partnership for African Development (NEPAD)[5]. Each institute is envisioned as a pan-African node with its own scientific theme in the field of mathematical science and its applications. Fritz Hahne cautions, however, that it takes a considerable amount of effort and commitment to make an institute like AIMS work. Establishing new nodes will depend critically on local leadership and support from governments. Two of the most promising proposals are for a centre for mathematical modelling in Ghana, at the campus of the University of Cape Coast, and for a centre for applied mathematics, with special focus on biomathematics, at the University of Makerere in Uganda. AMI-Net has been recognized by the African Union as a core component of Africa's Science and Technology Consolidated Plan of Action, requiring funding at a projected level of $30 million over the next five years[5]. Materials sciences form another core element of that plan.

We are convinced that these initiatives can prove extremely valuable for the future of science in Africa. AIMS has a unique philosophy, allowing it to operate and contribute in the context of Africa. It will be very worthwhile to use the fruitful model of AIMS also for scientific fields beyond mathematics. Physics and materials science are natural extensions. A complication is of course that teaching such subjects cannot be done without an experimental infrastructure, which brings practical and financial boundary conditions into play. Even more difficult will be to find inspired, level-headed realists such as Hahne and Turok to dedicate themselves to the cause. Africa does face very real problems, but the lack of infrastructure also presents opportunities where a lot can be achieved with relatively small means. As David Gross says, bringing students in contact with excellent local and foreign scientists in a programme that covers many of the most exciting areas of modern science has potential benefits for the scientific and technological development in Africa that are simply enormous.

Published online: 21 October 2007.

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Acknowledgements

This paper was supported in part by the National Science Foundation under Grant No. PHY05-51164.