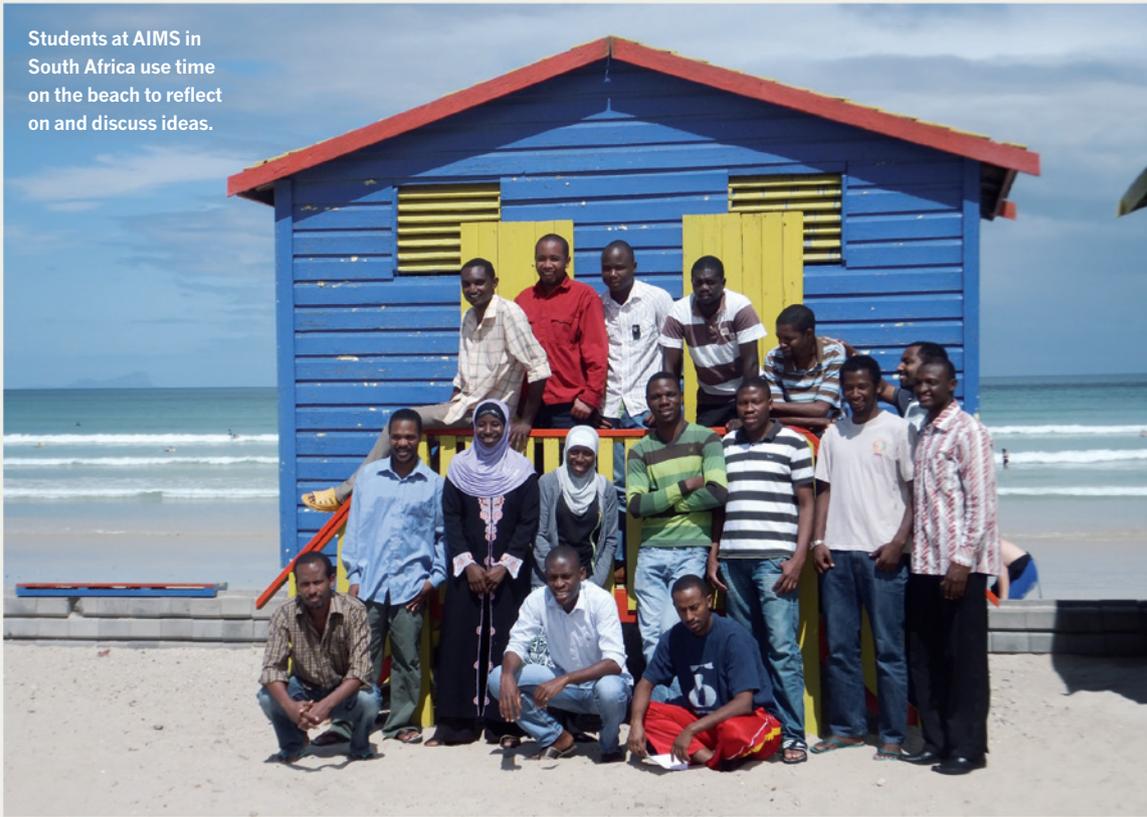


Students at AIMS in South Africa use time on the beach to reflect on and discuss ideas.



Africa's counting house

The African Institute for Mathematical Sciences was set up to breed a new generation of numerical talent. Now it is spreading across the continent.

BY LEIGH PHILLIPS

Alex Bamunoba is not quite sure how many siblings he has. “My father was polygamous, so we ended up being very many,” he says. “Something close to 30 brothers and sisters, with different step-mums.” But when it comes to the branch of pure mathematics known as number theory, Bamunoba is on solid ground. He won a place in a PhD programme at Stellenbosch University in South Africa, and he hopes to teach mathematics in his home country, Uganda, or elsewhere in Africa.

The bridge that took Bamunoba from a Ugandan village to Stellenbosch is the African Institute for Mathematical Sciences (AIMS). The aim of AIMS, which was started in 2002 by cosmologist Neil Turok, is to recruit the brightest students from across Africa and match them up with a faculty of top-tier

mathematicians, computer scientists and physicists from around the world for a one-year postgraduate diploma in maths. Turok argues that a generation of mathematically trained graduates will empower Africa by strengthening the continent’s research base and by focusing on fields that are key to industry and policy, ranging from mathematical modelling to computing, censuses and financial management. “There is nothing more cost-effective for development than mathematics,” says Turok, who is head of Canada’s Perimeter Institute for Theoretical Physics in Waterloo.

Ten years on, AIMS, based in Muizenberg, South Africa, has graduated 407 students, of whom 315 are still in Africa (see ‘Where the graduates go’). Around

40% have gone on to do PhDs, one-quarter are working in academia as postdocs, researchers or teachers, and nearly 7% are in industry. Turok’s team is proud to have produced statisticians for the Zambian Energy Regulation Board, systems engineers for Namibian IT consulting firms, epidemiology researchers in South Africa and lecturers at multiple African universities who in turn educate hundreds of students each year.

“What AIMS is doing is so important,” says Kwame Akyeampong, a senior policy analyst and mathematician with the United Nations Educational, Scientific and Cultural Organization (UNESCO) in Paris, who specializes in education evaluation. “Africa is deluding itself if it thinks it can produce a South Korea or a China without advanced maths and science training.”

NATURE.COM
For more on science
in Africa, see
www.nature.com/africa

AIMS-SOUTH AFRICA

Now Turok and his team are expanding. In the past 14 months, they have opened institutes in Senegal and Ghana. Next year, they plan to open a fourth in Ethiopia. Turok's long-term vision is a network of 15 such schools throughout Africa. "Our future goal is to have a major impact on Africa's development," says Turok. "This will require training large numbers — many thousands — of students, so they form a highly skilled community."

And to build that community, says Turok, AIMS is pioneering a new style of education. "We're reinventing the university," he says, "and if you want to do this, the best place to come is Africa."

EARLY INSPIRATION

Turok was born in Johannesburg, to prominent anti-apartheid militants. His parents were imprisoned for their activism, and his father is still an ANC member of parliament. Neil Turok left the country to pursue studies in theoretical physics in the United Kingdom and the United States. But he remained strongly connected to — and increasingly frustrated by — his home continent. "About a trillion dollars has been spent on aid to Africa over the past decade, with no obvious results," he says.

Part of the problem, according to Turok, is a lack of mathematical expertise in African governments. "They bring in consultants from Europe or buy off-the-shelf software that may not be appropriate. Major policy decisions are being made off the back of this with such poor understanding." Yet African education systems are in no position to fill the gap. "Universities over the past 30–40 years have suffered from chronic underinvestment, privatization, isolation and a terrible loss of morale," he says. "The teaching of mathematics and sciences has really been in crisis."

After Turok came up with the idea for AIMS, he convinced the South African theoretical physicist Fritz Hahne to become the school's first director. In 2002, using a 1-million-rand (US\$100,000) donation from the Turok family, the pair bought and transformed a rundown art deco hotel a street away from the beach in a small town 21 kilometres from Cape Town. In August 2003, with funding from international donors and the South African government, the institute opened its doors to the first 30 students. Today, the annual cohort stands at 50.

A visitor to the institute today steps off the scruffy yellow cars of Cape Town's metropolitan railway and smells the sharp tang of the Atlantic ocean. The beach and its crashing waves have long made this village, with its vegan café-cum-bookshop and marijuana-fragranced jazz hangout, a magnet for surfers and freethinkers. The peach-coloured institute, filled with utopian mathematicians, seems right at home.

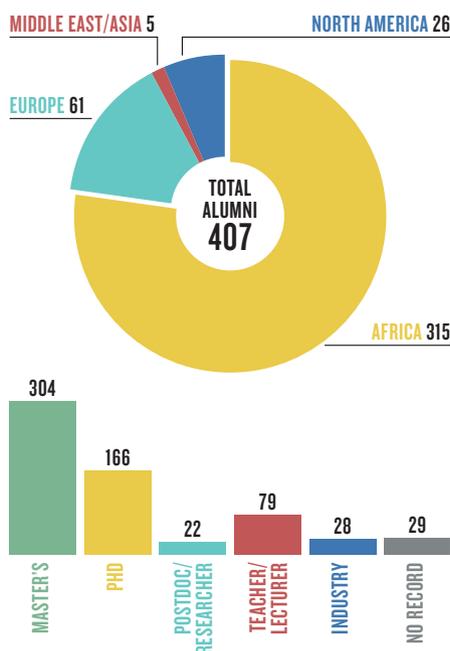
The programme is divided into three parts. An introductory phase ensures that everyone

has a common grounding in problem-solving and computing, and a good grasp of English. This is followed by intensive three-week courses in topics such as biomedical signal processing, quantum computing and natural-systems modelling, taught by instructors who fly in from around the world. All this is rounded out with a seven-week research project that can form the basis of doctoral work should a student decide to continue to a PhD. Students are tested in oral examinations rather than in written ones, in an effort to test their knowledge of ideas rather than their skill at passing a test.

The three-week courses have been key to the institute's success, says Turok. In the past year, course teachers have included 15 South African and 18 international academics, including mathematicians Laurent Lafforgue and Maxim Kontsevich, both winners of the Fields Medal (the International Medal for Outstanding Discoveries in Mathematics) and based at the Institute of Advanced Scientific Studies near Paris. The village's long, surfer-friendly beach is one attraction for instructors, jokes Barry Green, the school's director since 2010 and former head of Stellenbosch University's Department of Mathematical Sciences. "But more seriously,

WHERE THE GRADUATES GO

Most of the alumni from the African Institute for Mathematical Sciences have stayed in Africa and in academia.



it's because we're flexible. With courses three weeks long, it's easy for people to get away."

Juan Rodríguez Aguilar, a computer scientist at Spain's Artificial Intelligence Research Institute in Bellaterra, last year taught a short course on the programming language Python and, seduced by the experience, is back again this year. "It was so shocking when I first went to the lab," he says. "It slowly became clear that some people had never seen a computer

before. I was thinking: 'Where the hell am I?'" The level of interaction is intense, says Aguilar. Students work all hours and go for long walks on the beach to thrash out ideas. Instructors and students live on site and eat together in the cafeteria, where the lively discussion continues. "The schedule says we should be working with them for two hours a day, but really, it's more like five." And after three weeks, he says, "they were writing their own programmes, doing loops, doing integrals, derivations. I thought: 'This is just fantastic.'"

The institute's fees also set it apart. There are none: travel, accommodation, food and a stipend are all covered by AIMS, at a cost of roughly \$10,000 per student per year. Turok says that this is essential in a continent where some students wouldn't be able to afford even the plane ticket to Cape Town. AIMS South Africa now costs 18 million rand a year to run, with an extra 1.5 million rand for an enrichment programme for elementary and secondary school teachers and pupils and 5 million rand for the attached research centre. The South African government currently funds the school's infrastructure and research groups to the tune of 13 million rand, and tuition costs are paid for by donors.

Above all, the institute's success hinges on finding and recruiting good students, which it does through a network of trusted contacts in academia that keep an eye out for mathematical talent. Tina Ambinintsoa Malalanirainy Rakotoson, a tiny woman from Madagascar who writes down her name for a reporter to make sure it's not misspelt, wanted to come because her home country doesn't offer high-level training in the aspects of mathematics that fascinate her. She beams when she talks about the school and the thrill of being with students from across the continent. "Everybody speaks science. It's very exciting. It's not really like this back home," she says. "It's like a library with people instead of books."

INCLUSIVE APPROACH

But is AIMS helping Africa? The school's administration is certainly proud that most of its alumni have remained in the continent. "When students want to build their career, it's normal that they may want to go elsewhere," says Green. "But we want to have a significant number that stay." Students are instilled with the school's mission to help Africa, and its leaders often talk of its 'pan-African spirit' — a term from the days of anti-colonial and anti-Apartheid struggle denoting the unity of the continent.

Turok and his colleagues are also making tangible efforts to keep students there. In 2008, AIMS opened a research centre across the road from the main building, funded by the South African government to the tune of 5 million rand per year. There, current and former AIMS students mix with academics, postdocs and PhD students from elsewhere. "We realized we had created such a unique community.

Such highly motivated students,” Turok says. “Why were we sending them away? Here, they would be much more encouraged to do path-breaking research.”

The research centre hosts four research groups, which explore cosmology and astrophysics, mathematical biology, computational algebra and mathematical finance. “We picked ideas that were not very mainstream in Africa, but very modern, that could then be spun off to universities after ten years,” says Bruce Bassett, the ebullient head of the cosmology research group. With Africa’s sky-high incidence of HIV, malaria and tuberculosis, it was obvious to focus on mathematical biology, which can help to tackle such diseases through systems biology, for example, or epidemiological modelling.

The cosmology group, the largest at AIMS, is girding itself for rapid growth alongside the two giant astronomy facilities planned for South Africa: the Square Kilometre Array (SKA), a €1.5-billion (US\$1.9-billion) effort to build the world’s largest radio telescope (see *Nature* 485, 555–556; 2012) in South Africa and Australia; and South Africa’s MeerKAT, a giant radio telescope in its own right and the technology demonstrator for SKA. The group hopes to develop methods for handling the overwhelming amounts of data that these instruments will generate as they survey the sky.

The focus on cosmology and astrophysics, Turok admits, has prompted observers to ask: “What’s that got to do with Africa’s needs?”

“But that’s missing the point,” he says. “It’s not about bringing Africa up to some mediocre level, or worse, about mere survival. It’s about demonstrating that Africa can produce world-leading scientists.”

IN SEARCH OF EXCELLENCE

Charles Leadbeater, a London-based expert who has advised companies and governments on education innovation, compares AIMS to the Indian Institutes of Technology, a network of regional public engineering schools developed in the 1960s, and their successors, the Indian Institutes of Information Technology, which, he says, have been real drivers of the country’s development. He also praises AIMS’s intensive teaching structure. “There are really few places at any level that quite have that dynamic, highly creative, lateral community feel. It’s like going to Pixar or Google,” he says.

But Akyeampong says that higher education alone can’t drive Africa’s development. “What’s really lacking is excellence in maths education at the base” for children in their first few years of schooling, he says. “Until that is resolved, you are never going to get the critical mass of mathematically literate that will have the serious impact on development that the AIMS people are hoping for,” he says.

AIMS has had its rough patches. The South African government has long demanded more return on its investment, and pushes AIMS to take in more domestic students. AIMS



Neil Turok (centre) is trying to inspire young Africans to pursue careers in mathematical sciences.

“There is nothing more cost-effective for development than mathematics.”

responded by adding a second intake in January — after South Africa’s summer — to fit with the country’s educational timetable and open it up to students.

And the expansion of AIMS to other countries has caused growing pains. Funders were sceptical, and a partnership to start an AIMS centre with the African University of Science and Technology (AUST), a private university set up by the World Bank in 2007 in Abuja, Nigeria, foundered. One reason, says Turok, is that the AUST charges US\$20,000 a year, but AIMS insisted that all costs be covered. “They also don’t emphasize the importance of having women students the way we do,” says Turok. “We have a minimum placement of 30% women students. They have two to three women out of a hundred students. From our point of view, this is unacceptable.” After the first flush of success with the South African campus and initial efforts to expand, “we seemed to be in danger of losing momentum”, says Jan Groenewald, an IT specialist at AIMS.

But in 2008, Groenewald says, things started to go their way. An AIMS alumna Esra Khaleel from Darfur in Sudan came up with the idea of an ‘African Einstein’. Turok adopted that branding, and the proposed network of institutes became known as the ‘Next Einstein Initiative’. “It turned out to be a hit with students and funders,” Groenewald says. “Then things started to move really fast.” In 2010, Google awarded AIMS US\$3 million to the project, and last year, the

Canadian government committed Can\$20 million (US\$20 million) over five years. The initiative now encompasses an office in Cape Town with more than ten full-time staff, as well as the new centres in Ghana and Senegal. As the centres proliferate, the plan is to open neighbouring research groups with their own mathematical specializations. The Senegal institute in M’bour, 80 kilometres south of Dakar, will be specializing in mathematics associated with solar energy and erosion — two natural topics in a country threatened by a steadily advancing Saharan desert.

Hahne, who continues to teach at the school, says gruffly that he is not fond of the branding. “I’m not looking for the next Einstein,” he says. “I’m looking for the solid development of science in Africa.” But Turok, who says that the Perimeter Institute has now modelled its one-year master’s programme on AIMS, is clear that there is substance beneath the slogan. “Africa is the greatest untapped pool of scientific talent anywhere, and no one realizes this,” he says.

Rakotoson does. Although some of her friends back home also like maths, they enter finance “to make money”, she says. “They don’t love mathematics. I love it!”

“Do you want to know why?” she asks, leaning forward, as if divulging a secret. “It’s because it’s like a game. When you know all the rules, you’ll always win.” ■ SEE EDITORIAL P.159

Leigh Phillips is an International Development Research Centre fellow at Nature.