

Astronomy Education & Outreach in South Africa

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Although South Africa has evolved greatly in the 20 years since the end of apartheid, it remains a very divided country. The highest-performing students are comparable in ability to those in the US and Europe, but nearly all of these students are from privileged Afrikaner (European) backgrounds. The vast majority (~90%) of students in the country are native African, and school standards remain very low across the country. It is common that students have no textbooks, teachers have only a high school education, and schools have no telephones and no toilets. By high school graduation, the majority of students have never used a web browser -- even those in the capital of Johannesburg. And while a few students are inspired by home-grown world-class projects such as the Square Kilometer Array (SKA) and Southern African Large Telescope (SALT), most remain unaware of their existence.

Despite the poor state of education in the country, students work hard, are curious, and desire information from and contact with the developed world. Astronomy is one subject in which students in rural Africa often show exceptional interest. Astronomy serves as a 'gateway science,' linking the physically observable world, the textbook world, and the exotic and unknown.

During 2012-2015, I made more than 40 visits to rural and urban schools and school groups in South Africa during 2013-2015. I interacted with thousands of K-12 students — as well as the broader public — through school visits, science festivals, museums, radio / TV / print interviews, township science centers, homegrown youth programs, and more. I report on these activities and give some general thoughts about means of effective outreach in the developing world.



Under African Skies
More than 500 students, teachers, and parents observed the moon and Jupiter at a night-time viewing session at Madikweng Senior Secondary in Limpopo.

“Scientific endeavour is not purely utilitarian in its objectives and has important associated cultural and social values. It is also important to maintain a basic competence in flagship sciences such as physics and astronomy for cultural reasons. Not to offer them would be to take a negative view of our future - the view that we are a second-class nation chained forever to the treadmill of feeding and clothing ourselves.”

— SKA South Africa Proposal Study, 1996



Madikweng Senior Secondary, Limpopo
Building model comets is just as much fun in Africa as anywhere else.



New Facilities at Madikweng
This chemistry lab was recently retrofitted by a donation from a South African private foundation (Old Mutual). The school recently received government funds to build pit toilets; until 2014, they had none at all.

State of Science Education in South Africa

The vast majority of K-12 students in South Africa attend public schools. At the end of grade 12, they take a month-long national standardized exam which tests their knowledge in areas such as Physics, Mathematics, English, Geography, and Zulu. The score required to pass is only about 30%, so while the number of high school graduates is on the rise, the majority of them are unqualified by Western standards.

The majority of high school students:

- Fail basic math problems (e.g., -1 + 2).
- Have never used a web browser
- Have neither toilets nor indoor plumbing at their school or home.

Many schools have no textbooks, and teachers often have little more than a high school degree.

Approximately 25% of graduates go on to do some study at a university or trade school, and a few percent of high school graduates will complete a four-year degree program.

After graduation from university, black South Africans are in high demand. Despite this, the unemployment rate among the black community exceeds 50%, and many jobs that qualify as "full employment" are on the informal economy - picking up trash, or selling fruit for a few dollars a day.

South Africa's regional and national universities are high quality, although tuition remains inaccessible to many (*cf.* 2015 student protests). Third-party scholarship programs such as those from the SKA, the US Embassy, and the MasterCard Global Scholars Foundation have substantial benefit, although are not large enough to support all qualified students.

The vast majority of black south African students are not only first-generation college, but first-generation high school as well. Their parents had very little ability for employment beyond physical labor, and the effects of these restrictions continue to have a huge impact on students of today.



FameLab - Talking Science
FameLab is an international science communication festival sponsored by the British Council. It has run for three years in SA, sending contestants to the finals in the UK every year.



SciFest Africa, Grahamstown
This government-supported science festival attracts upwards of 70,000 K-12 students every year. Participants — including busloads of school groups from across South Africa, Botswana, Namibia, and Swaziland — participate in a week of workshops, seminars, lab visits, and one-on-one discussion with national and international scientists and engineers.



Astronomy Club
These students reached out and personally invited me to visit their school. In addition to giving several talks to the school, I arranged for the donation of a 4.5" reflector. We spent the evening observing the Moon, Jupiter, Saturn, and a few constellations, and talked about sunspots and telescope operation during the day.



Mae Jemison Science Reading Room
Talking with students at a US Embassy-run science library for K-12 students in the Mamelodi township, near Pretoria.

What I Did in South Africa

I lived in South Africa from 2012-2015. I spent about 10% of my time conducting outreach activities:

- Full-day + evening visits to rural village schools
- Talks to K-12 school groups
- Talks at community groups, science clubs, and museums.
- Radio interviews in rural and urban markets
- Lectures at astronomy festivals
- TV interviews
- Science fair judging (ISEF-affiliated)
- FameLab judging and consulting
- Presentations and workshops at SciFest Africa festival
- Google hangouts with worldwide audiences
- Judging and speaking at NASA *Space App Challenge*
- Lectures and observing with SA Youth Innovation Conference
- Talks and workshops with local government groups to build US-SA ties and strengthen local education programs
- Advice and encouragement to many first-generation college-bound students.

I reached additional students as a faculty member at the University of Pretoria. This was 'whites-only' school during apartheid, which now has an enrollment of ~50% first-generation black African students.

- Observing trips with students to national facilities
- University lecturing (3 full courses, including the first Astrobiology course taught in Africa)
- Field tips to local sites such as the Tswaing impact crater and the NASA-built Hartebeesthoek Radio Observatory.



Hard-Working Teachers
These four teachers are the science department at Dendron Secondary in Limpopo. Many of the teachers live away from their families and send money home, because the \$700/month salary at this school is far higher than they could earn at home.



Dendron Senior Secondary, Limpopo
I spent a day and a half at this high-achieving rural school. Students stay at school until 11 PM, and the school has a nearly 100% graduation rate.



Marks Mokwele
Mr. Mokwele, here a 12th grade in rural Limpopo, is now entering his second year as an engineering student at the University of Pretoria.



Physical Inspiration
These calendars, provided by NASA's Planetary Science Division, were a big hit at Dendron Secondary. The school does not have internet connection, so cannot access web pages or streaming video, putting many E/PO products off-limits for them.



Ponelopele Oracle School, Tembisi, Johannesburg
This township school was built by the Oracle Corporation, and operated publicly. I spoke to an audience which included the family of the highest-achieving student in SA's 12th grade national exam.

Tips for Outreach in Developing Countries

Web pages and online video are inaccessible to many students. Only 3% of South African houses have broadband internet, and the majority of residents don't have internet access through a mobile phone according to a 2015 UN report on global internet access. Individual students may have internet access on their phones, but it is very slow — *e.g.*, they can use messaging applications such as WhatsApp, but not YouTube.

Physical objects — DVDs, photos, books, stickers — have substantial value. DVDs can be played in schools with no internet connection to watch online videos. Modern, well-written science books at an accessible level are of immense value to motivated students. Even NASA mission stickers and prints are inspiring, because they remind students of their own future possibilities, and the interest the rest of the world has in them.

Personal visits provide long-term inspiration for students and their community: “*Your visit with us [to talk about New Horizons] was perhaps the greatest event that has ever happened in this school's 10-year history,*” according to one teacher.

Students in rural areas are often inspired by dark skies, but without a culture of academia and media they rarely learn the constellations or motions of the planets by themselves.

Even in a country with the world's largest radio telescope (SKA Square Kilometer Array, under construction) and the hemisphere's largest optical telescope (SALT, Southern African Large Telescope) telescope, most students have never heard of them. Outreach by the government and others can strongly leverage the investment in these facilities. Ironically, **most South African students know more about NASA's Mars rovers than they do about their own country's world-class astronomy projects.**

When visiting schools, **kids love you, always.** You are an instant rock-star the moment you mention working with NASA or astronomy. Having this connection from the start makes it easy to start talking about real science.

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