Strengthening African Machine Learning

Outcomes of the
First Deep Learning Indaba

Held in September 2017, Johannesburg, South Africa

November 2017

The
Deep Learning
Indaba

Strengthening African Machine Learning:
Outcomes of the first Deep Learning Indaba.
Issued November 2017.

Quotations in this document have been minimally edited for grammar and readability, and come from participant feedback.

Typeset in Maven Pro.

Principal author and contact: Shakir Mohamed.
info@deeplearningindaba.com

This report can be viewed online at
deeplearningindaba.com/reports

Indaba 2017 Organisers

Shakir Mohamed, Staff Research Scientist, DeepMind.
Ulrich Paquet, Staff Research Scientist, DeepMind.
Vukosi Marivate, Senior Researcher, Council for Scientific and Industrial Research, and Visiting Researcher, University of the Witwatersrand.
Willie Brink, Senior Lecturer, Stellenbosch University.
Nyalleng Moorosi, Senior Researcher, Council for Scientific and Industrial Research.
Stephan Gouws, Research Scientist, Google.
Benjamin Rosman, Principal Researcher, Council for Scientific and Industrial research (CSIR), and Senior Lecturer, University of the Witwatersrand.
Richard Klein, Associate Lecturer, University of the Witwatersrand.

A Personal Message

On the 10th of September this year, we took our first uncertain step through a doorway. For all the months prior, starting in February, we operated in the realm of imagination, of planning, of spreadsheets and budgets, driven by a mission to 'Strengthen African Machine Learning'. Crossing the threshold that Sunday afternoon, we entered an environment that was everything we had hoped for. We had seen the creation of a new community, one united not by historical injustices, but by a shared commitment to science and learning, and the potential it has to transform our societies for the better. We executed a technical programme of sharing, teaching and debate around the state-of-the-art in modern machine learning, whose mastery is essential to realising the vision of a transformed and prosperous continent. And we saw Africans, from across the continent and in all its diversity, represented and included.

Our ambition grew over the course of these few months, from a small series of lectures, to what would be one of the world's largest teaching events in machine learning. In total we had almost 300 participants, representing 22 African countries and 33 African research institutes. Our participants shared a common theme in their hopes for the Indaba: they each hoped to build their own confidence and ability to make contributions in this area of science; they wished to inform their future career trajectories; and importantly, they sought a vision of the role that machine learning can play within their communities and local problems. And as much as they hoped to learn from us. as we sought to better understand how African machine learning can be strengthened we hoped to learn from their experiences, their challenges, and from their excitement around all that might be possible with machine learning. This is the true spirit of an Indaba, and why it is so named; we hoped to build on the traditions of our past to strengthen our culture of scientific exchange, and in so doing, the foundations of our future.

Deep Learning Indaba Organisers,
November 2017

Contents

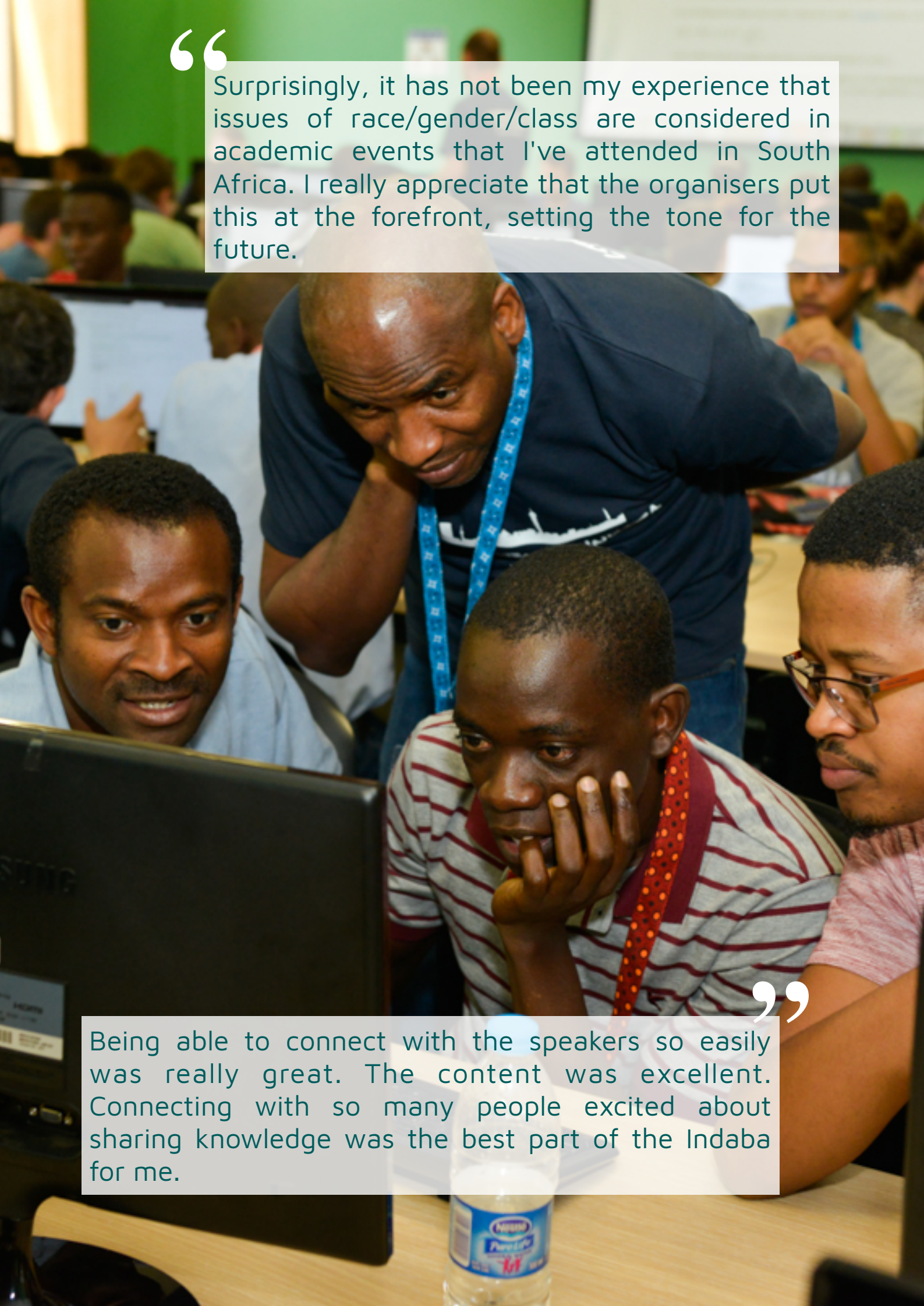
1. Introduction

The first Deep Learning Indaba was held in Johannesburg, South Africa from 10-15 September 2017. The Indaba was a week-long event of teaching, sharing and debate around the state of the art in machine learning and artificial intelligence, and aims to be a catalyst for strengthening machine learning in Africa.

Much of the wider discourse at present is permeated with conversations around the 4th industrial revolution, the need for policies and interventions around changes to jobs and workplaces, the impacts of increasing automation in societies, of high-levels of global investment in AI and machine learning, and visions of AI-first organisations. What underlies these conversation is the ongoing and rapid advances being made in artificial intelligence. It is essential for Africans to become not just observers of the ongoing advances in AI, but active shapers and owners of these technological advances. It is for this reason that the Indaba was conceived. And for this reason it plays a unique and important role within our continent.

This report outlines the lessons learnt during our experience of the first Indaba. It outlines our understanding of the current state of African machine learning and AI. We expand on the reasons behind the Indaba's inception, expand on the format that it took and why, the challenges we see facing students and academics, who form the foundation of an African AI innovation ecosystem, and the challenges of diversity and the ways that these can be addressed in the field.

We hope, and intend, that the Deep Learning Indaba will become an annual event in the African calendar; forming a connected pan-African machine learning community, all working to use this technology for the betterment of our communities and continent. We hope you will gain insight from this report, and use it to make your own contributions to strengthening African machine learning.



“Surprisingly, it has not been my experience that issues of race/gender/class are considered in academic events that I've attended in South Africa. I really appreciate that the organisers put this at the forefront, setting the tone for the future.

Being able to connect with the speakers so easily was really great. The content was excellent. Connecting with so many people excited about sharing knowledge was the best part of the Indaba for me.”

2. Recommendations

These recommendations address the challenges and limitations we identify in this report, and will be put into the future organisation of the Deep Learning Indaba.

1. Widen African participation

The Indaba will put increased emphasis in ensuring that a greater number of attendees come from countries outside the host country. To ensure this, specific allocations of the Indaba's operating budget should be allocated to supporting wider participation. This will need to be achieved by increasing the financial support-base from sponsorship and grants, and also by engaging government support and bilateral relationships that exist between African countries. This pan-African participation remains a core value of the Indaba, and is essential for creating a fluid, united and wholly inclusive African machine learning community.

2. Continued emphasis on diversity, inclusion and community-building

Diversity is a driving principle of the Indaba, and we strive to work to greater inclusion in all aspects of the Indaba, whether this be among the organisers, speakers or participants. Further emphasis will be given to creating more intimate spaces to allow attendees to overcome social barriers and to better understand their different backgrounds, contexts and experiences; this is essential to creating a unified African research community. Challenges in identifying a diverse pool of applicants, and tutors for the practical sessions, will be addressed by relying on Indaba alumni that have now been established, and by earlier recruitment.

3. Participation from all stakeholders

The Indaba must include not only more African participants from outside the host country, but should engage further with universities, research councils, academics, local businesses, startups and African venture capitalists. The Indaba must ensure that impact and success are not seen as activities that can only occur abroad, but that highly successful and impactful careers are already possible within our continent.

4. Influence a change in South African research funding policy

Research funding schemes, particularly from the National Research Foundation (NRF) in South Africa, work against the aims of building strong collaborations and a unified research community. A common experience is that of siloed research environments, and institutions being disincentivized from collaborating due to the way in which research funding is allocated. The Indaba should engage directly with these stakeholders to create a deeper understanding of the experience of the climate of fast-paced global publishing and scholarship in machine learning and artificial intelligence.

5. Increase student mentorship opportunities

The Indaba should ensure that mentorship is built into the fabric of the Indaba. The opportunity to engage with speakers must be part of the programme of the Indaba. Explicit mentorship sessions should be included to give

students the opportunity to learn from established researchers from different institutional backgrounds. Greater awareness of local mentors should be incorporated. The Indaba should also work to extend beyond its principal week-long event, but work to engage communities and research groups at other times of the year: the experiments with the Indaba meetup events will give the needed insight on this.

6. Expanded participation of academics

A limitation of the first Indaba was that there was limited participation from academics. A truly inclusive community and meeting of the African research community at the Indaba is not possible without greater participation of academics and researchers.

7. Establish a careers fair

The Indaba risks leaving the impression that successful and impactful careers are only possible outside the continent. To address this, the existing framework around sponsor areas for job opportunities will be widened. This will take the form of a much expanded careers fair that will include a broader array of participants, including universities, large banks (which were already well represented), other large industries in telecommunications, mining and agriculture, larger cohorts of startups, charities and NGOs, policy think tanks and consultancies, and venture-capital and investment firms.

8. Selection process

Significant policy innovation will be needed to balance skills levels and academic achievement, against the Indaba's aims to spark curiosity in those with potential as well as to contribute towards historical redress. The Indaba will also look to re-examine sources of potential bias in any form, like those due to language proficiency, institutional backgrounds, or other sources.

9. Improve the learning experience

The practicals will be split into two levels of expertise to better cater and allow for a smoother learning experience. Explicit aspects of the budget should be allocated for computing infrastructure to ensure that the ability to run on GPUs or other computational platforms is easily available.

“It was great to see the diversity of people participating in the machine learning community across Africa. With external funding and inspiration from experts in the field, I have high hopes for the important problems we can collectively solve in Africa.

Working on artificial intelligence is quite challenging in my department at university, since knowledgeable faculty just don't exist. An event like this is so motivating and creates such fantastic networking opportunities. Beyond that I learned so much. I am so inspired and I have a much better idea of what a career in machine learning might look like.”

3. State of African Machine Learning

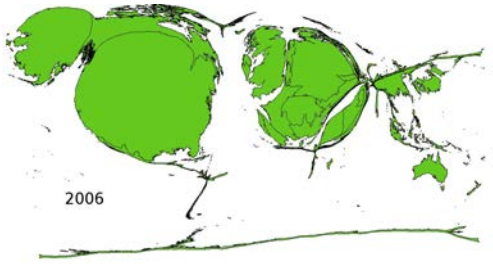
African Research in Machine Learning

African machine learning exists in various forms, and several examples of impactful work exists. To support the food security of our nations, computer vision is used to detect cassava root disease in images captured using low-cost mobile phones[1]. Where health services and advice is limited, especially for HIV and AIDS, machine learning is used to shorten response times in mobile question-answering services, allowing these services to reach more people[2]. And the African contribution to Big Science, in particular in radio astronomy through the square kilometre array telescope, will advance the state of machine learning to provide new insights into the workings of the universe[3]. Often, these instances exist in isolated pockets and without the resources to allow their full impact to be reached.

A Case Study in International Participation

To understand the participation of African research groups in the international arena, we posed a simple question: At the leading machine learning venue, the annual Conference on Neural Information Processing Systems (NIPS), how many accepted papers in 2016 came from research groups on the African continent? Or to be more general, how many accepted papers have at least one of its authors from a research institution in Africa? The answer: zero.

What if we extend this to the last ten years. For African research groups the answer remains zero. In contrast, at NIPS 2016, the list of accepted papers included more than 150 paper authors from the United Kingdom, while more than 1000 paper authors were affiliated with American institutions. From this analysis, we would conclude that our continent is missing from the contemporary machine learning landscape. This is what we mean when we say that African participation in machine learning is low.



Area cartogram showing the lack of African publications at a major machine learning conference[4].

The are many factors that affect these participation levels, including skills shortages, researcher confidence, squeezed funding, infrastructure constraints, and inadequate public policy, amongst others[5,6]. But the data does show that change is achievable. In 2006,

[1] John Quinn , Kevin Leyton-Brown , Ernest Mwebaze, Modelling and monitoring crop disease in developing countries, AAAI 2011.
[2] AI helps answer thousands of health queries in Zambia via SMS, New Scientist, 2016.
[3] Melanie Johnston-Hollitt, Taming the Data Deluge to Unravel the Mysteries of the Universe, WWW17

[4] Missing Continents: A Case study using accepted NIPS papers.
[5] P. Lee. African universities need improved research strategies.
[6] Africa Union Commission. Science, Technology and Innovation Strategy for Africa 2024.

Indian institutions also had zero accepted papers at NIPS, but are now represented by 20 paper authors each year on average. China shows this same trend even more markedly. There is much to learn from the strategies they have used in strengthening their research communities.

The questions we asked are, of course, highly simplified. We would need to further interrogate the data and any systematic errors it might have. We only looked at accepted papers, not submissions. There are many African researchers who are based at institutions beyond our continent. We have also not looked at other conferences, although for many, long-term statistics are not currently recorded.

Global Machine Learning Landscape

There is an anticipation, both from academia, industry, and also government policy, that advances in artificial intelligence will bring about disruption to a number of traditional industries. In broad brushstrokes, this could be seen in the number of new academic centers, like Oxford's Future of Humanity Institute or the Leverhulme Centre for the Future of Intelligence. Some governments alike try to strategically invest to benefit maximally from whatever disruption artificial intelligence might bring about, and this is embodied from changes to investment in education, to equipping local industry to be leading players in the "next wave".

The global focus on this is emphasised by the policy documents and reports issued by several countries. Some notable documents over the last 12 months are:

- Growing the artificial intelligence industry in the UK . UK government report, October 2017.
- Next Generation Artificial Intelligence Development Plan, Government of China, July 2017 (English translation).
- Machine Learning: the power and promise of computers that learn by example. The Royal Society, April 2017.
- Preparing for the Future of Artificial Intelligence, US government, December 2016.
- Artificial Intelligence, Automation, and the Economy, US government, October 2016.

A common thread in these strategies is that there are a number of players that need to co-operate. The most comprehensive and ambitious of such plans is arguably China's, which outlines a strategy that reaches from basic research to industrial application, with five-year milestones towards 2030. It should by no means be taken as a verbatim example, except that:

1. The strategy clearly outlines where "there is still a gap between China's overall level of development of AI relative to that of developed countries".
2. The strategy states the requirements for success.
3. The strategy shows clear technical insight, insight into possibly changing markets, and next steps.

It reads as a highly directed technical plan that could be executed in a measurable way, almost like a start-up's business plan.

It is unclear whether any African government has produced the same level of directed thinking: stating where the

continent is at present, and stating how progress is to be made from that point. In South Africa, the Department of Trade and Industry is in the process of producing a white paper, mentioned here, that mentions 'artificial intelligence'.

Basic Skill Levels

From the data we obtained from potential candidates we gained an insight into the basic skill levels in our pool of applicants (see figure 1).

The academic transition of students is clear by looking at the percentage of applicants in different occupational roles. There appears to be a steady transition of students from undergraduate into masters level study. After this point, most students seem to move towards industry, and some to research degrees. Even fewer move to post-doctoral studies. The reasons for limited transition from masters to PhD degrees is not clear from this simple analysis, but we hope that the Indaba provides more compelling understanding of what a research degree in the field means, and of the viability of research and opportunities for long term and high-impact careers. The lack of progression from masters to PhD to post-doctoral level will have impact on the wider availability of academic mentors, which is a concern and challenge we identified facing students (see later sections).

Most students, when asked to self-assess their technical skills, were confident in the two areas that are the core foundations needed for a deep understanding of the machine learning. This is a testament to the excellent higher-education obtained by students from African institutions.

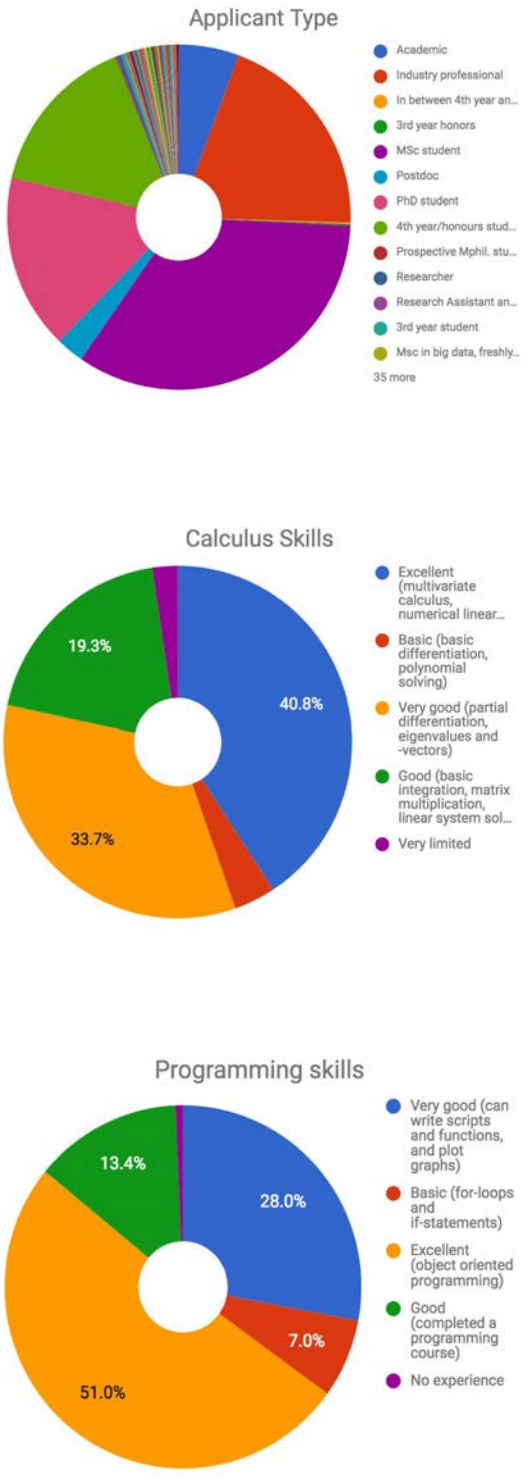


Figure 1: Applicant occupations and their self-reported skill levels.

Similar Events

The Indaba was created to fill a need for advanced training and community building in artificial intelligence and machine learning in the continent. It remains unique amongst events, but there are several other events that are aligned with our mission and take slightly different formats and scopes.

- Data Science Africa. This annual event, now in its 3rd year aims to create a hub in the network of data science researchers across Africa, and have thus far explored areas of East Africa. They work on a structure of a 3 day summer school and 2 days of workshop. Being the closest in spirit to the the Indaba, we hope to forge closer connections with DSA.
- PRASA-RobMech International Conference. This incorporates the Annual Symposium of the Pattern Recognition Association of South Africa (in its 28th year) and the Robotics and Mechatronics Conference of South Africa (in its 10th year). This is the premier South African conference in areas around machine learning and robotics, and is typically a two day conference with an additional day of workshops, and usually falls under the IEEE.
- SKA Machine Learning summer school. A 10-day programme aimed at introducing fundamental data science tools and techniques to talented young science graduates across a range of disciplines, who have an interest to develop their skills and knowledge in working efficiently on extremely large datasets in any research environment.
- AIMS Data Science Workshop. This workshop run by the African Institute for Mathematical Sciences (AIMS) in South Africa, explored the mathematical underpinnings, computational challenges, and applications of Data Science. The programme, now in its second year, covered some topics also covered at the Indaba, but had far fewer attendees and was restricted to South African students.
- Neuroscience Imbizo. A 3 week-long summer school to share ideas and techniques around the state-of-the-art in computational neuroscience. The second year of this summer school will take place in Muizenberg, South Africa, January 2018.
- Grace Hopper Celebration. The Grace Hopper Celebration is the world's largest gathering of women technologists. The 2017 event hosted 18,000 women, and has been held annually since 2006. The Indaba's values are closely aligned with the GHC, and much can be learnt from their success and growth.

African Research Institutions

Based on our pool of applicants we can identify several institutions with some capacity, or seeking to build capacity in the areas of machine learning, deep learning and artificial intelligence. A list of institutions and names of some academics leading the efforts is listed in Appendix D.

This Indaba was a life changing experience for me, and it got me very excited for my future. In particular, it convinced me to do a PhD and push myself even harder to do well. Thank you!

You did an amazing job getting people to the party but not everyone knows how to get the best out of it. [...] I think more interactive group sessions might be useful for breaking some of these barriers.

4. Aims of the Deep Learning Indaba

Why a Deep Learning Indaba

The Deep Learning Indaba aims to address two principal aims: African participation and contribution to the advances in artificial intelligence and machine learning, and diversity in these fields of science.

1. African participation in machine learning.

The solutions of contemporary AI and machine learning have been developed for the most part in the developed-world. As Africans, we continue to be receivers of the current advances in machine learning. To address the challenges facing our societies and countries, Africans must be owners, shapers and contributors of the advances in machine learning and artificial intelligence.

It is of critical importance that we develop the technical skills needed to address these challenges. This need is only highlighted in the context of the investment and national strategies and policies that we see for other countries and multi-national organisations, and highlighted in the previous section. Our focus is on students and teaching, since these people will become the future PhD-level researchers, supervisors, research scientists, and innovators and entrepreneurs that will embody our continent's participation and command of the field.

2. Diversity in AI

Aspects of diversity are of increasing importance in the field of machine learning. It is critical for Africans, and women and black people in particular, to be appropriately represented in the advances that are to be made. It is critical for the the future trajectory of the field, and for the types of teams we build and problems we address, that this imbalance and lack of representation be addressed. There is an increasing awareness of the problems of algorithmic bias: the development of machine systems that encode societal biases with potentially detrimental or discriminatory effects. Africans have a critical role in ensuring that these biases can be detected and addressed in the original design of these algorithms. As countries of black people, we have it in our power to address these issues.

***

The implications of these overarching goals is the *spreading of technical* knowledge at the state-of-the art in the field; the o*pportunities for new research connections* to be made and and silos in the research community to be broken; the fostering of a *better understanding of the variety of career paths* in the field, especially those that are in abundance locally; and through new friendships, perspectives and backgrounds, taking the steps to realising a *more representative, inclusive and multicultural machine learning community*.

Why the Name `Indaba'

Those outside Southern Africa may not be familiar with the term indaba. An indaba is a Zulu word for a gathering or meeting. Such meetings are held throughout southern Africa, and serve several functions: to listen and share news of members of the community, to discuss common interests and issues

facing the community, and to give advice and coach others. This is one of many words used, including an imbizo (in Xhosa), an intlanganiso, and a lekgotla (in Sesotho). And by other words in other parts of the continent, such as a baraza (in Kiswahili) in Kenya and Tanzania, and padare (in Shona) in Zimbabwe. And of course this connects us to community gatherings that are similarly held by cultures throughout the world.

This spirit of coming together, of sharing and learning is one of the core values of our meeting, and hence, the best choice of name for it.

5. Structure of the Indaba

Overall Structure

The Indaba was structured as a 5-day event of master classes and practical sessions, in which participants would be exposed to the state-of-the-art techniques in deep learning and machine learning. The Indaba's structure was unique in that it was designed to merge the style of popular machine learning summer schools with the style of a major machine learning conference. The teaching sessions followed the format of a typical summer school with lectures from leading experts in the field. We followed the conference format in having industry representation and industry recruitment stands, poster sessions that reflect the intensity and format of the major conferences, as well as social events as part of the programme.

Application and Acceptance

We asked applicants to apply to attend to allowing us to select applicants in order to: choose those that would benefit the most, choose applicants that showed potential and curiosity, and to create a lever that could be used to promote more representative participation. We asked all applicants to rate themselves in terms of technical skills: their ability in calculus, ability in programming, and ability in linear algebra. We also asked applicants to provide motivational statements, CVs and contact details for supervisors. Data of these skill levels was shown previously, in figure 1.

We aimed to not look at any CVs or ask for references unless needed, since this can lead to selection biases and is often not informative. We took applications from students at all levels of study, but prioritised post-doctoral candidates and PhD students first, then Masters students, and then undergraduates. We allowed for students who were transitioning to a next degree and who may not be currently enrolled at a university. We had a selection panel of 3 organisers who ranked applicants by looking at the combination of skill levels and motivational statements. We then formed three groups of clear accept, clear reject, and borderline. We offered places to all applicants in the clear accept category and from the borderline group up to the capacity we could accommodate. We had a cap for industry participants of 70.

This process was expectedly hard to get right. We ultimately had a higher reliance

on motivational statements and the weight of this may not have been clear to all applicants. Greater clarity to applicants, and a more structured rubric for selection going forward will be put in place. We will also expand slightly on questions on skill levels and prior experience, to better shape this process.

General Programme

The general programme was designed to inspire and invigorate. We aimed by the end of the week, for participants to be enthused about research in machine learning, have clarity about the careers and future prospects in this area, and have heightened awareness of available role-models and existing local capacity in the field. This was achieved by:

Structured curriculum. The curriculum began with foundational material, and progressed over the course of the five days to advanced topics at the state-of-the-art. We could not cover all topics that attendees may have wished to have covered, but have managed to expose all attendees to the topics that are now driving current research and new technologies in the field.

Split between local and international speakers. In inviting our speakers, our aims were to showcase the diversity of everyday scientists, to show that there are many curved paths to a machine learning career, and to build confidence and technical skill in our attendees through the experiences of our chosen set of scientists. We have both African speakers to show the strength of technical capacity held locally, and international speakers who will bring with them the state-of-the-art in the field. In total, 18 speakers formed the core of our technical programme. We asked each of these speakers to share the story of how they got into machine learning, what they will be teaching us, for their advice, and what they see as challenges for the future. These speakers gave their time, money and energy to join us at the Indaba, and were key to the success of the Indaba.

Speaker diversity. We worked to ensure that our speakers represented the true diversity reflected in our society. Many groups do not have the levels of representation that should be expected, especially in fields of science and high-tech. Many groups do not have the levels of representation we would expect, and this was something we were mindful not to reinforce, and to work to actively correct. Machine learning scientists come from every technical background imaginable: probability theory and statistics, physics and economics, neuroscience and psychology, operations research and signal processing, and many beyond. These scientists are also men and women, are Africans and Asians, are black and white, are lesbian and gay and transgendered. They come from every part of the world, speak in different languages and accents, hold different beliefs, and are shaped by different histories. Amidst all this diversity, they are singularly committed to discovering the principles of learning in brains and machines, and to the beneficial applications of this knowledge. Our chosen set of speakers embodied all these characteristics.

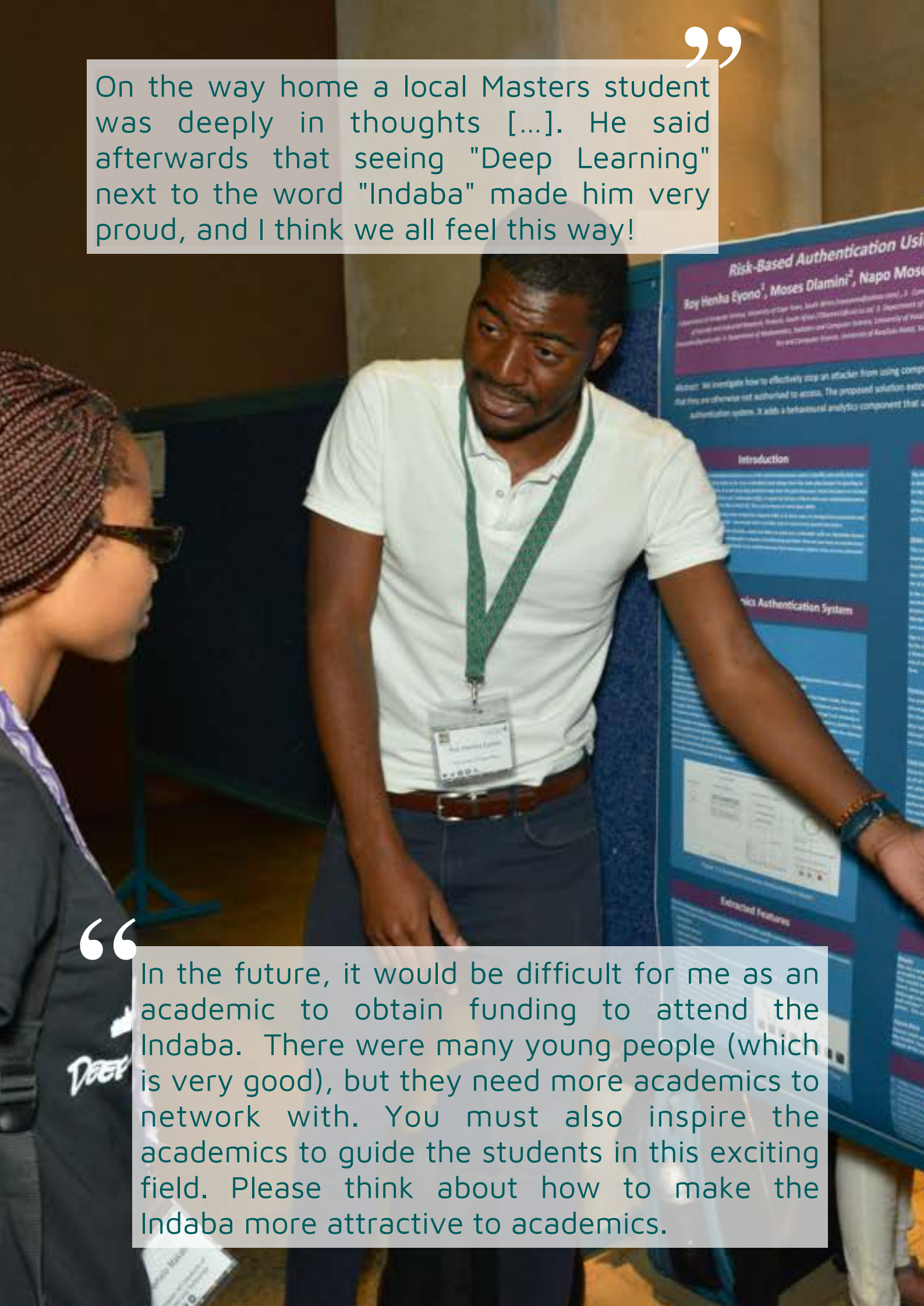
Practical sessions. For each of the major topics, we had corresponding practical sessions that allowed attendees to build practical experience in developing their own solutions in code

using a modern programming environment and testing them within a modern computing framework. Attendees found these challenging, but they are essential to make progress in this area of science. In future we will create two streams to better shape the experience of attendees at different skill levels.

Sponsor stands. We wished for attendees to have direct access to local companies to see what career paths exists, and to have direct opportunities for future employment. We hoped this would create the sense of an extended career fair. The inclusion of a specific career fair will be made an explicit component of subsequent Indabas.

Networking sessions. A vibrant research community requires a community that is built on knowledge of the potential partners and collaborators that are available. Mutual understanding and willingness to work together is needed for this, and for this reason it was important for the Indaba to create explicit spaces for everyone to mix. Historical divisions, in South Africa in particular, can continue to permeate, and this aspect of community building was important to address. While we had a diverse grouping, many did not have the tools to break down their barriers and really start to mix and engage widely. This is expected to some extent, and future Indaba will look to create more of these spaces and in varied forms to help equip attendees with tools for more mixing between attendees.

Celebrating research excellence. In total, 157 posters were presented at the Indaba, and covered every topic imaginable: diagnostic tools for breast cancer, malaria and tuberculosis; ways to address water management in areas that are experiencing severe water shortages; machine learning in mining and mineral extraction; much needed tools for support, analysis and translation of local languages; the analysis for astronomical data generated by the Square Kilometre Array telescope; or even using machine learning to characterise the structure of large prime numbers. The diversity and quality of work was astounding. To celebrate the effort made by students, and to further support their research and their home institutions, we subtly deployed a panel of judges comprising our invited speakers, to score each of the posters. We identified 37 students as winners of prizes. These students have demonstrated true excellence in research. The prizes ranges from trips for two students to the leading conference in machine learning, graphics processing units for computation, and several book prizes from the Cambridge university and MIT presses. The use of prizes and celebrating research excellence will be an ongoing element of the Indaba



On the way home a local Masters student was deeply in thoughts [...]. He said afterwards that seeing "Deep Learning" next to the word "Indaba" made him very proud, and I think we all feel this way!

In the future, it would be difficult for me as an academic to obtain funding to attend the Indaba. There were many young people (which is very good), but they need more academics to network with. You must also inspire the academics to guide the students in this exciting field. Please think about how to make the Indaba more attractive to academics.

6. Diversity and Inclusion

Bias and Fairness

One of the aims of the Indaba is to ensure that we build a more racially representative and multi-cultural machine learning society. The reasons for this are only emphasised when we see evidence of the ways in which machine learning can be used without careful thought. Some of the recent examples include: tools to predict criminal re-offence, that are biased against black people[7]; algorithms that encode biases against women[8]; claims of developing systems that can detect gay people from images[9]. Examples like these are increasingly common. A more diverse group of scientists and research teams from all walks of life is the first step to avoiding these types of flawed and biased systems from being developed. In addition a discussion around ethical and societal impacts of AI will be included into the programme of future Indabas.

Student Support

The Indaba was designed to ensure that it is as inclusive as possible. We attempted to do this at all levels: at the application process, at registration, and in the means of attending the Indaba.

Application process. We hoped to avoid the self-selection problem associated with other events and recruitment processes. We asked students to rate their own skills as a way to make the expectations of the Indaba clear, we did not ask for any letters of reference from supervisors, and we asked every applicant to motivate what they hoped to gain from attendance and what they hoped to achieve. We received almost 750 applications, a high burden of review but one we welcomed since it was a strong indicator of the relevance and role of the Indaba..

Registration fees. To ensure that students would not be deterred due to financial means we ensured that there would be no registration fee, and that this registration fee would cover all costs, which included facilities costs, breaks and lunches, and our opening and closing events, amongst others.

Travel and accommodation support. We also sponsored 70 students with travel and accommodation to Johannesburg. Due to financial constraints, most of these students were South African students, and this lack of funding to support travel from many further regions was problematic. Our student support included 66 South Africans, 10 Batswana, 2 Malagasy, 1 Namibian, and 1 Zimbabwean.

Figure 2: Nationalities represented at the Deep Learning Indaba.

[7] Pro-publica. Machine bias.
[8] Wired. Machines taught by photos learn a sexist view of women.
[9] Wired. AI research in desperate need of ethical watchdog.

Outreach and Recruitment

To reach as many parts of South Africa and of the continent, we relied heavily on the database of academics and researchers maintained by the Modelling and Digital Science unit of the council for scientific and Industrial research, and their alumni. We also sent personal communications, used social media platforms, and through the organisers own personal networks.

Outreach was also done after the recruitment. The Indaba was highlighted at the Data Science Africa (DSA) 2017 Workshops in Arusha, Tanzania (meeting the organisers of DSA and two future Indaba 2017 participants), and at the Data Science workshops at the African Institute for Mathematical Sciences, which also had a number of future Indaba 2017 participants. We also reached out to groups using the Black in AI network, Dev Center Slack Group (2000+ members in West Africa), ZA Tech Slack Group (2000+ members in South Africa).

We created the *Machine Learning and Data Science Africa Network mailing list*. This was composed of our initial lists and applicants to the Indaba; now with 1000 members. We hope for this list to be a unified platform for communication between groups across the continent.

Gender and Racial Representation

The field faces the dual challenges of a lack of gender and racial representation. These issues are compounded in the South African setting given the historical disparities of the country. These are issues we hoped to report on, measure, and address over time.

We designed the application forms with the intention to reduce barriers to entry, and to ensure that no one was discouraged from attending. We also encouraged the champions of the Indaba that we reached out to in the advertising and recruitment phase to specifically encourage women to attend. A first overview of the Indaba in terms of demographics and ethnicity is given in figures 3 and 4.

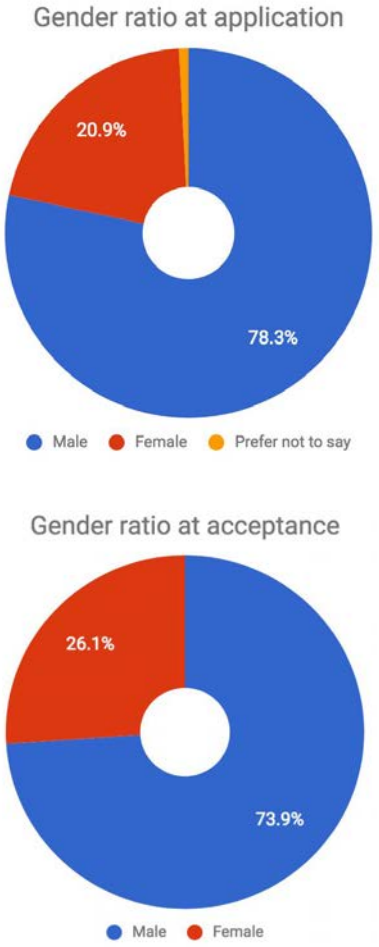


Figure 3: Overall gender breakdown at application and acceptance stages..

These graphs give a coarse view of the makeup of the attendees, and how this changed between application stage and acceptance. The Indaba was noticeable in that 26% of its attendees were women, increasing the percentage at application.

Yet, at the same time, the percentage of black students, in particular, does have this same effect. Our selection process, given the tight time frame in which we operated the first Indaba, did not allow us to fully utilise the levers of transformation available to us.

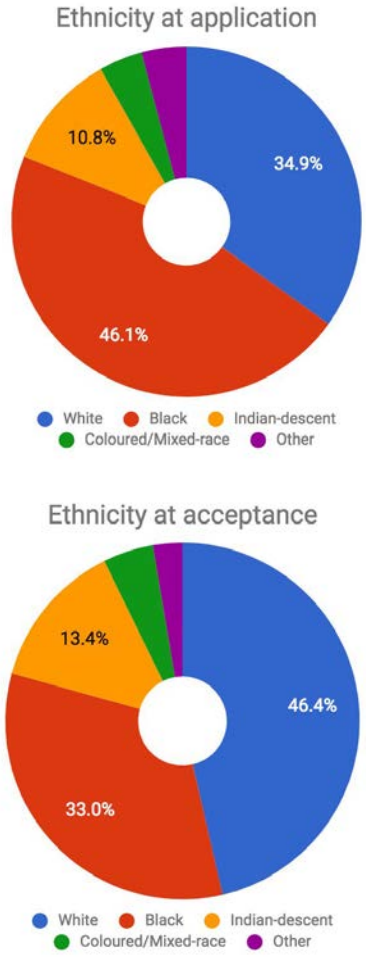


Figure 4: Overall ethnicity breakdown of the 2017 Indaba.

This coarse view also hides some of the structural elements that contribute to this demographic makeup. As a starting point we can look at the number of academics that applied to participate in the Indaba in figure 5. The graphs show that there are significant imbalances: there are very few academics in general in the field; of these, there are fewer black academics, and then fewer black and female academics. This seems to highlight an issue of mentorship and training, and this dearth will have an effect on the composition of research students. We can only make these statements to the extent that we had academics who applied to participate in the Indaba, and we will need to focus more effort to convince academics that their participation will be a beneficial investment of time.

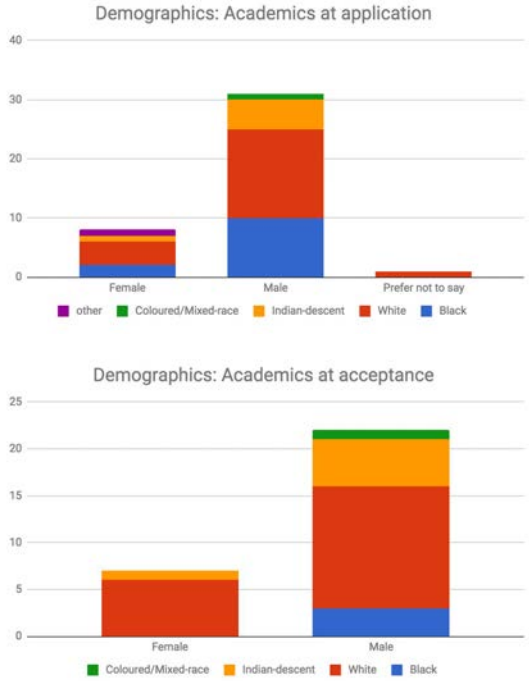


Figure 5: Demographics at application and acceptance stage of academics.

We had an encouraging number of applications from undergraduates, at all stages (figure 6). The proportions at application stage show a positive trend to balanced representation, and through further refinement of the selection process, we will be able to assess what was lacking in maintaining this balanced state into the acceptance phase.

There is a similar positive trend when we examine research candidates (Masters, PhD and post-doctoral candidates, figure 7). Our selection process was aimed firstly at PhD students, of which there are fewer candidates (c.f. figure 1), then

Masters students, of whom there are many, but who do not move on to further research. We again need to reassess selection process and whether we had the information needed to assess the potential and aptitude of applicants.

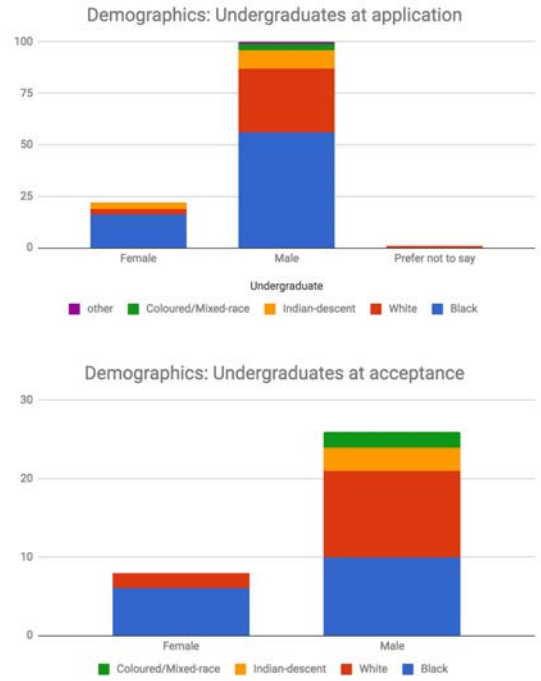


Figure 6: Demographics at application and acceptance stage of undergraduates.

The Indaba recognised that it must include all stakeholders from students, academics, entrepreneurs, and industry. Industry stands to make immediate benefits from advanced machine learning techniques. The students in attendance also needed to see clear career paths to become fully convinced of the benefit of the personal investment they would make in higher-education, whether that be in the founding of new startups, in education sector, or opportunities in established businesses.

For this reason, we had a large industry contingent, and their demographic makeup is shown in figure 8. Industry in general has very limited representation of black participants (again restricted to what we can say based on applications to the Indaba, and to the extent that this can be used a rough measure of the industry as a whole). This is a further aspect of our application and selection process that will require further refinement.

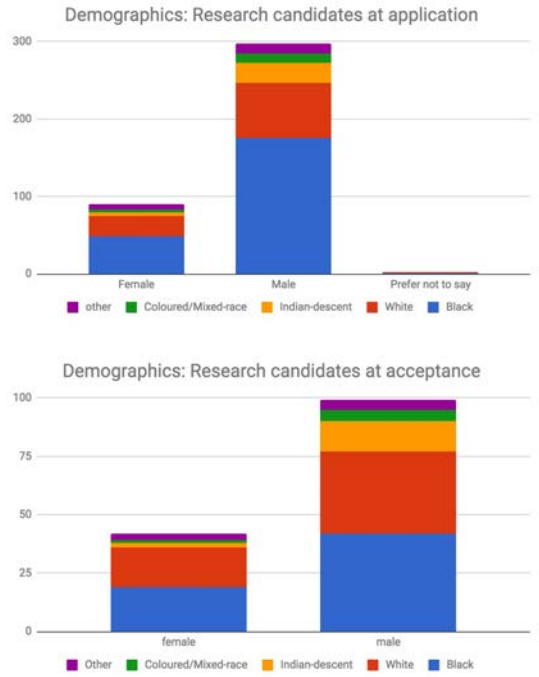


Figure 7: Demographics at application and acceptance stage of Research candidates.

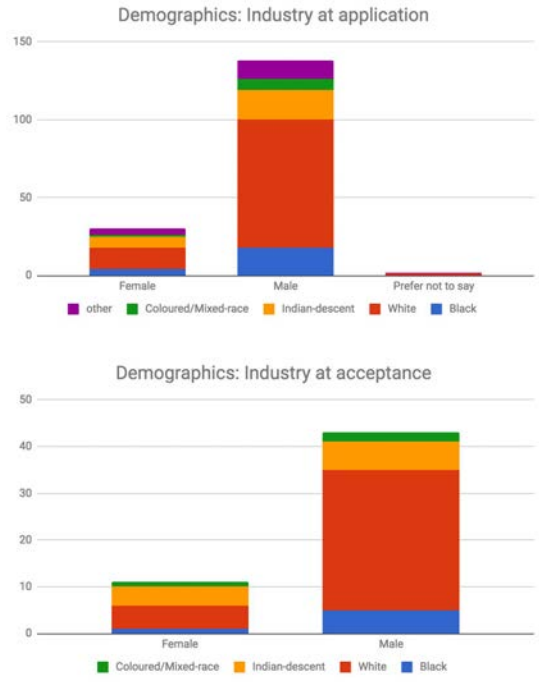


Figure 8: Demographics at application and acceptance stage for industry participants.

7. Financing the Indaba

Cost Areas

To achieve the aims of the Indaba, we allocated our total budget in three broad areas:

Student Support	R313,255
Facilities, infrastructure	R133,230
Events and catering	R1,147,839
Total	**R1,594,324**

This budget was allocated to support 350 attendees. Student support included the full support for travel to Johannesburg and accommodation for 70 students, and ensuring that there were no registration fees for any students and postdocs. Facilities and infrastructure entails registration materials, conference shirts, welcome bags, poster boards, and personnel costs. The facilities costs are not higher because of the partnership with the University of the Witwatersrand, which was essential. Events and catering is the largest part of our budget and included daily lunch, coffee breaks, the evening meals for our poster sessions, and our opening and closing events.

Ethical Spending

We endeavoured, to the extent we could, to ensure ethical and inclusive spending. Our welcome bags were created by a local business that is run and owned by women communities in the north of Gauteng. Our opening event was managed by an up-and-coming women owned event management team. Our flexibility with this is restricted by procurement systems of the host university, and greater flexibility on this will be sought in future.

Funding Sources

Our sponsors by design are a mix of international and local organisations. We made special emphasis to have many local organisations as supporters to indicate that there are several opportunities and commitment to machine learning in Africa.

For this initial event, we did not have a tiered sponsorship scheme to gauge the commitment from local organisations, and had funding at various levels. Our sponsors were DeepMind, the University of the Witwatersrand, RetroRabbit, Standard Bank, the Department of Science and Technology (DST), Google, the NRF/DST Centre of Excellence in Mathematical and Statistical Sciences (CoE-MaSS), ABSA Bank, Opti-Num Solutions, IBM, Makro, the African Institute for Mathematical Sciences, PROWLER.io, and the Council for Scientific and Industrial Research (CSIR); see also Appendix B. Unsure of the response and appetite from sponsors, we did not use a tiered sponsorship scheme, but our sponsorship roughly fell into three categories: entry level at R50,000, a second group around R150,000, and a higher tier of R300,000 and greater. DeepMind was our largest sponsor.

Future funding rounds will be done according to a tiered sponsorship offering with the full legal documentation in place at the outset. The appetite from industry is large. They were asked to pay R2000, and the fee for these attendees shall be increased to a more representative level to ensure an income source that allows all the elements of the Indaba that could not be funded to be included.

Prize Sponsors

To inspire, recognise and celebrate excellent work showcased by students at the Indaba we reached out to several organisations to sponsor prizes. Our prizes included:

- Two fully funded travel awards to the world's leading conference in machine learning, the annual conference on Neural and Information Processing Systems (NIPS) in Los Angeles, supported by the Praekelt Foundation and DeepMind.
- Three NVIDIA TitanX Graphics processing units, the computational platform that enables modern deep learning, sponsored by the NVIDIA corporation.
- Ten books from the Cambridge University Press and 20 Books from the MIT Press.

What Could not be Funded?

We have organised one of the largest machine learning teaching events globally and our large numbers meant that there were several areas that could not be funded.

- We were not able to support the travel of as many students from outside South Africa as we would have liked. Even travel to our neighbouring countries can be very expensive. To truly enable African Machine Learning, we require increased funds to ensure that the Indaba, in whatever country it is held, can have strong representation from the collective of our African fellowship.
- We were unable to fund our speakers both locally and internationally. This meant that our speakers through their own sources, generosity and commitment to our mission found the funding to enable their travel to Johannesburg.
- Cloud computing with GPUs is essential, and part of our sponsorship or budget must include this availability.
- Financial fees, administration, legal, and web services were not accounted for and provided by the host institution. We expect that many of these services will continue to be provided as part of the partnership with future host institutions, but we should be able to support the cost of these services.

Projected Financing Needs

The Indaba can grow in several directions. The easiest of these is in size. Other aspects include through the creation of satellite events, and through spreading to different locations. A simple projection based on size-growth at different scenarios indicates our projected funding needs.

Currently: R1.6m/£90,000/$118k
Amount for 2017 Indaba, as a baseline.

Fully-funded: R2.38m/£130k/$171k
If all the amounts that we did not fund were included, then this is the approximate budget required, which includes the cost of travel for 15 international speakers, and 30 African students from outside the host country.

2X model: R5.5m/£300k/$396k
This is the approximate budget for an Indaba two-times the size of the current format. Costs will not scale linearly since an event for 700 attendees places different venue, administrative, events management and structural constraints. Using an Indaba in South Africa as a

prototype, this includes 60 non-South African students, and 15 International speakers.

10X model: R64m/£3.5m/$4.6m
While the Indaba is unique amongst events of its size, an event 10 times the current size is rarely seen outside large conferences and industry events - never for teaching. There will be a need for significant creativity from the curriculum and events committees, and cannot be contained within an institution of higher education. Looking at the growth and scale of the Grace Hopper Celebration is a useful exemplar.

8. Importance of Host Institutions

The Indaba was purposefully hosted at a university. This partnership both strengthens the local institution and allow us to help showcase the capacity of the host institution in machine learning and AI. Since the Indaba is not an officially established organisation, this partnership is also essential to its success, since the operational capacity is derived from the university host itself.

The University of the *Witwatersrand was an invaluable partner* and host of the 2017 Indaba. We were hosted within the modern facility of the Wits Science Stadium with access to state of the art lecture theatres and 3 adjacent lab spaces. The space of the Science Stadium formed the perfect setting for an Indaba dedicated to learning and exchange. Without the full support of Wits University, and in particular the Faculty of Science and the School of Computer Science and Applied Mathematics, the Indaba would not have been possible. The host institution offers several important facilities that are essential.

Lecture and lab space. We had the high requirement of a lecture theatre with a capacity for 400 people, as well as lab spaces with computing facilities that could account for 300 students. This was a high-requirement, but the excellent facilities at Wits, and the technical services from lab managers and assistants from the Mathematical Sciences laboratories, meant that this was easy to achieve and a testament to the excellent investment in teaching facilities made by the University.

Finance and administration. The funding of the Indaba is derived from several sponsors and spent from a project account run through the host institution. All the facilities needed for this, such as USD transfers, bridging funding, invoicing and receipts, flight payments, and procurement are all run through this facility. The financial administration fees were waived by Wits University for this initial Indaba, but in future, we will look to ensure that our funding includes the fees that make all this possible.

Legal and risk services. Dealing with sponsors requires contracts to be negotiated, operational safety to be considered, and and relevant policies

from university and city regulations to be applied for and complied with. The hosts institutions legal, insurance, risk, health and safety, and security teams are essential to making this happen.

Events management. It is natural to partner with the host institution's events management team to arrange everything from coffee breaks and lunches, to poster boards, tables for registration and the sponsors area, and for access to the range spaces appropriate for different types of events.

Communications. Part of the media and communications strategy was coordinated with the communications team of Wits University. This is essential in creating awareness around the aims of the Indaba, greater awareness of the important role of artificial intelligence in the future of our continent, and the importance of diversity in the field.

Networks and computing. The use of moderns techniques, like online Q&A tools, the practicals being run through cloud computing services, and the general need for connectivity, makes an event specific internet that is easy to access and reliable essential. The involvement of systems and networking teams is essential. We were not able to reliably ensure this, and reliable connectivity will be highlighted in future.

This list forms the requirements and level of involvement needed from future host institutions. We believe that this type of partnership can be beneficial to both the Indaba organisers, its attendees and the host institutions, and we look to empower more institutions in this way.

9. Ongoing Challenges

Limited Communication and Mentorship

One of the major challenges facing a strengthened African machine learning community is a lack of mentorship, a limited number of research groups in the field, and limited awareness of those that could offer this type of mentorship.

A common discussion in both the planning of the Indaba and during the event is the *siloed nature of the African academic community*. Such silos mean that different groups are not aware of each other and their mutual interests, and wastes the opportunity for cross-pollination. A deliberate aim of the Indaba was to break such silos by bringing different groups together. We hope our continued efforts will bridge these different groups across the continent.

Many students felt that they had limited mentorship, and did not know where to reach out for supervision and strong support to pursue further research in this area. Having limited supervisors means that fewer students move from Masters degrees into PhD and post-doctoral phases, which would then add to the base of future mentors. We hope as a first step, that being brought together is a first step towards creating this peer mentorship. We hope to include specific

mentorship sessions during the next iterations of the Indaba. Our ongoing work will be to attempt to create mentorship schemes, through peer mentorship, by supporting more local Indaba-like events, and a volunteer scheme to match students to available volunteer mentors.

Research Policies on Funding and Collaboration

A general difficulty faced by researchers at both local universities and research institutes is a misalignment of incentives with international trends. Two notable examples of this are publishing formats and collaboration.

For many decades, the primary venues for publications in machine learning (and more broadly computer science and engineering) have been conferences rather than journals. This is a result of the increasingly rapid changes in the field. However, unlike other disciplines, computer science and engineering conferences have the full papers thoroughly peer reviewed, the proceedings are archival and published, and the major ones have very low acceptance rates (of 15-20%). In this way they could be thought of as journals with a rapid turnaround time. The result has been that all of the most prestigious venues (and certainly the best venues for building international reputations) are conferences, and few continue to publish in journals. Despite this, South African institutions consistently incentivise researchers to publish in journals over conferences, leading to poor dissemination of local work, thereby harming the reputations of the local community.

The second major issue is the way in which universities are financially incentivised for publications, which has the monetary value divided by the number of authoring institutions. This then filters down into the institutions themselves, which regard a collaborative paper as being worth less than a solo-institution (or author) paper. For example, the CSIR even divides credit by the number of authors on a paper, when considering promotions. This all has the disastrous effect of discouraging collaboration between institutions, enhancing the silo effect. It further discourages local researchers from reaching out and forming international partnerships, which would build local reputations by association.

These problems need to be urgently addressed at the policy level, such that high-ranking conferences in the relevant subfields of computer science become regarded as equivalent to their journal counterparts. The value of collaborative work also needs to be emphasised, if critical mass is ever to be developed. Collaboration is becoming increasingly vital, as the complexities of these fields grow, and there is a great danger of our researchers being left even further behind.

Challenges facing Academics and Researchers

Some of the challenges facing students are consequences of the challenges facing academics. Some of the issues around siloed research institutions and limited mentorship discussed above are part of this issue. Another issue facing researchers is limited awareness of opportunities available, limited infrastructure (such as intermittent

electricity supplies), and a lack of experience in applying to international granting agencies. Where we can, the Indaba hopes to create more opportunities for mentorship for academics themselves around submitting grants in topical areas and of the standard expected, making more visible pointers to available resources, and mimicking the networking for student participants, to stimulate similar networks for academics and researchers.

Impression of Brain-drain

We were conscious to leave the message that a successful career in machine learning on the continent is already possible. For this reason, we worked to ensure that there were many different local organisations from universities, start-ups and large corporates, all involved to show the different career paths. Ongoing emphasis on this message is needed though.

A large part of the Indaba's funding came from international organisations, and many of our international speakers came from international technology companies. This risks leaving the impression that the best work is happening in the large tech companies, and in countries outside the continent, and that one must leave the continent to have an impactful career in the field.

These issues touch on the issues of local capacity and mentorship mentioned earlier, and also on issues of 'brain drain' that came up during the Indaba. Our aim is to empower, and contribute to the training of as many skilled workers in this field, and a critical mass of expertise in this area will assuage concerns in this regard. Our continuing effort will be to engage a wider number of local organisations in machine learning, to continue to trade-off the subliminal messaging given through the choice of speakers and sponsors, improved dialogue with participants during the Indaba around these concerns, and engagement with policy makers and leadership around ways to further address this.

Selection

The selection of participants requires ongoing refinement, since it is the key tool with which we are able to influence and empower the next generation of machine learning experts. Our selection process attempted to trade-off selecting those with proven track record, but also recognising future potential, addressing historical imbalances (racial representation) and ensuring that other forms of imbalance (gender parity) or lack of inclusion for any other reason (e.g., disability, language, orientation) is not perpetuated. Our view sees the Indaba as a tool for transformation and we continue to look into this aspect very carefully. We asked applicants to rate their skills and the effectiveness of these questions will be reviewed. We also heavily relied on motivational statement from applicants which can easily bias us to those who have strong command of English. We shall continue to experiment in all aspects of this process.

Difficulty in Selecting Tutors

The smooth running of our practical sessions relied on the identification of students who could act as tutors. Being the first Indaba, it was difficult to identify candidates for these roles. In addition, we also struggled to reflect in these tutors, the diversity of people, especially of black students and women, who could

act in this capacity. Future Indabas will be able to rely on students that have been identified from previous years. This is also a process, which for the 2017 Indaba, was not started early enough. Both the challenges of identification and diversity can be addressed by earlier and more structured search for tutors.

10. Outcomes and Call-to-Action

The graphs in this section work on a scale from 1 of *strongly disagree* to 5 of *strongly agree*.

Sharing Knowledge Beyond the Indaba

The Indaba was host to 300 people, with representatives from 22 African countries, comprising 33 African research institutions. But we received more than 750 applications. For every person that attended the Indaba, there was more than one person who we could not accommodate. This makes it critical for us to take our knowledge and experiences and to share it with others.

To make this possible:

- All the tutorial talks are recorded and available online to re-watch and share.
- The practical material is available for everyone to use, teach from, and modify.
- We'll have pages on our website with other useful resources (including other learning materials, scholarship and funding opportunities, and infrastructure resources).
- And we now have a Machine Learning and Data Science in Africa network mailing-list a way to connect to the continental community working in machine learning and data science in all its forms so we can more easily ask each other questions, share research and job opportunities, and build collaborations. This list has almost 1000 members.

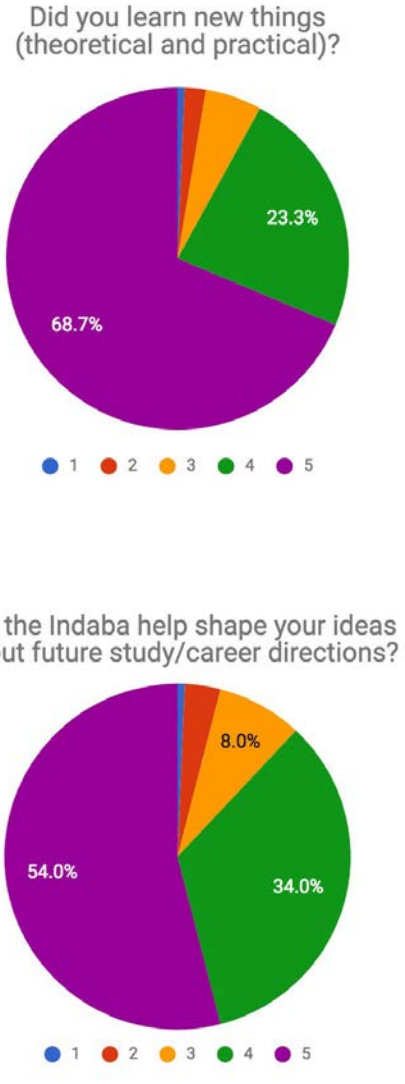


Figure 8: Overall positive feedback from attendees. Rating: 5 (strongly agree), 1 (strongly disagree).

The Talking Drums of Africa Renewed

We leave the legacy of this Indaba to its participants. To each participant we asked, to take their experiences and lessons learnt, and replicate it in their universities, residences, labs, and offices. To spread their understanding of machine learning. In this is the way, they will take ownership of the field; how they will strengthen African machine learning.

The drum language of the Kele people, sophisticated and proud, once spread knowledge to the far reaches of their communities. These talking drums of Africa are no longer with us. But they can be renewed, in us. As the Indaba closed, we used this as our call-to-action: *to be the talking drums of Africa renewed*. To share what we know. To carry our lessons as far as we can. To use it for the good of our societies. To work towards a shared purpose that secures our continent's place at the rendezvous of victory.

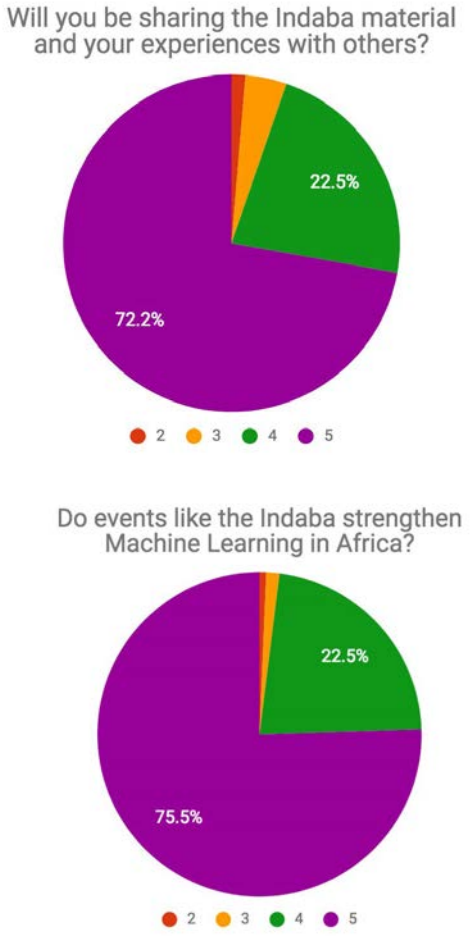
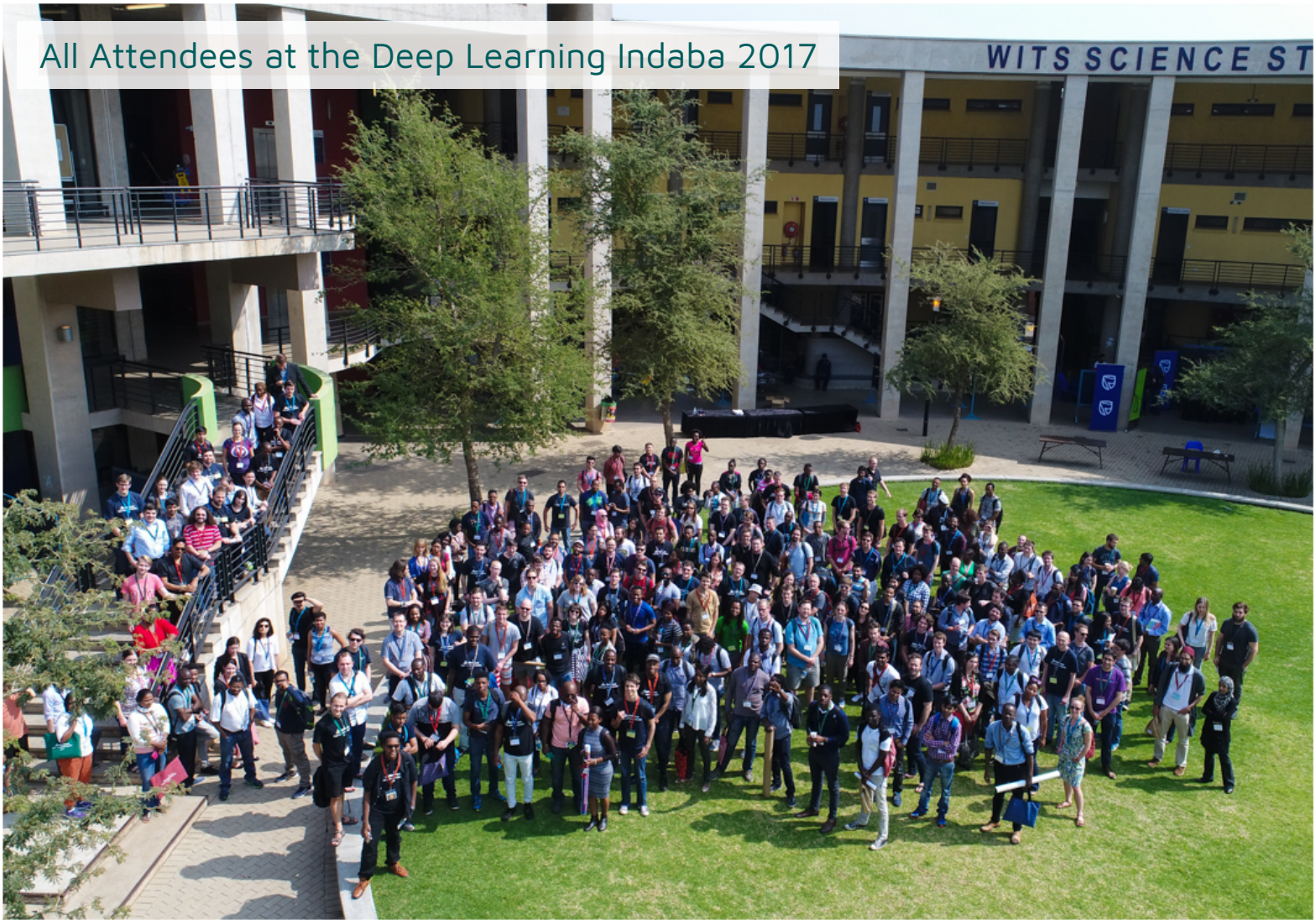


Figure 9: Overall positive feedback from attendees. Rating: 5 (strongly agree), 1 (strongly disagree).

All Attendees at the Deep Learning Indaba 2017



African Women in Machine Learning

11. The Future

As a committee, we are more enthused and committed than ever before to our mission of strengthening African machine learning. The success of this first Indaba has given us the momentum and confidence to be more ambitious, to grow and innovate in all aspects of the Indaba's organisation, and to create a more constant flow of activity and events. The Indaba will change rapidly over the coming years, but we are committed to seeing it become an annual event that will move to different parts of the continent and with more local leadership.

Deep Learning IndabaX

To maintain the momentum and excitement generated by the Indaba, we will be working with groups from all the institutions represented at the Indaba to host their own smaller, independent Indaba-like events. These IndabaX events will be coordinated across all institutions within the same week in April 2018, to create a week of discussion around machine learning spread throughout our continent. We hope these satellite events will add to the local leadership in the field and give more exposure and opportunity to local research groups. This week will also coincide with the closing of our applications for the next main Indaba, which we hope will ensure that we continue to maintain a pool of high-quality and diverse candidates.

Indaba 2018 and 2019

The Indaba will now move to a two year planning cycle. The 2018 Indaba will be in South Africa, and we are in the process of identifying the host of the 2019 Indaba. We host the Indaba in South Africa one more time to capitalise on the momentum that has been built from this first Indaba, and to further experiment with elements of the Indaba experience (those listed in the recommendations in the opening of this report).

Expanded Committee and Advisory Board

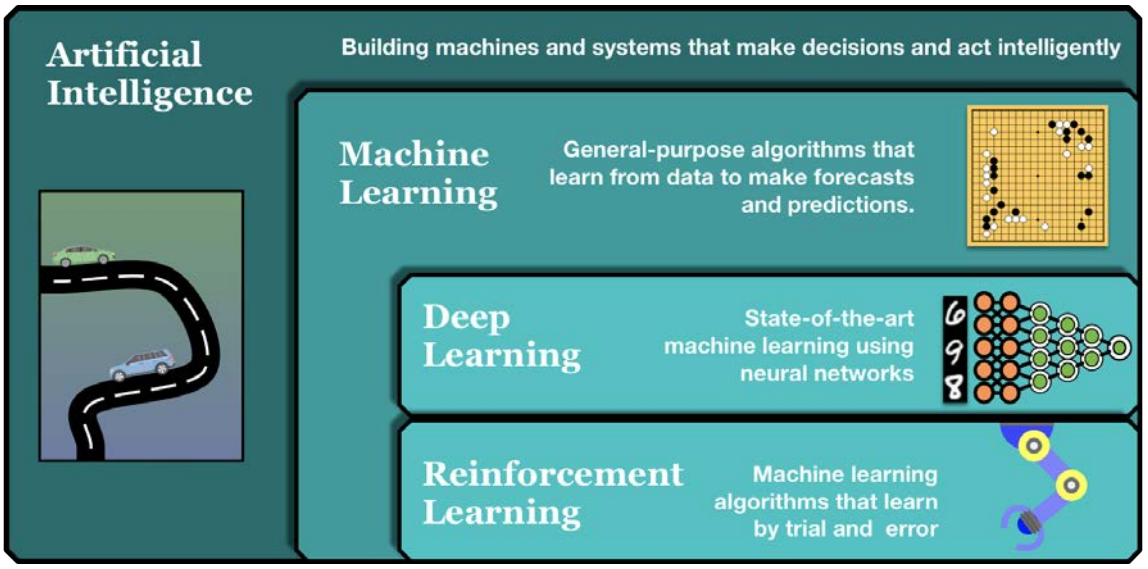
Our committee will be expanded greatly to have a larger representation of voices from the other countries, and to more widely share the expertise being developed through its organisation. We plan to announce our expanded committee and reconstituted advisory board at the end of 2017.

Your Support

To achieve the aims of the Indaba, we will require ongoing support from all sectors. If you, an organisation, or any other stakeholders you know can support our mission in any way as a financial supporter, as a prizes sponsor, in outreach, fundraising and awareness, or other ways please reach out: info@deeplearningindaba.com

Our first Indaba has taught us much.
We now continue on our path to strengthening African machine learning.

Appendix A: Artificial Intelligence, Machine Learning and Deep Learning



Appendix B: List of Organisers and Advisory Board for 2017 Indaba

Organising Team

- Shakir Mohamed, Staff Research Scientist, DeepMind
- Ulrich Paquet, Staff Research Scientist, DeepMind
- Vukosi Marivate, Senior Researcher, Council for Scientific and Industrial Research, and Visiting Researcher, University of the Witwatersrand
- Willie Brink, Senior Lecturer, Stellenbosch University
- Nyalleng Moorosi, Senior Researcher, Council for Scientific and Industrial Research
- Stephan Gouws, Research Scientist, Google
- Benjamin Rosman, Principal Researcher, Council for Scientific and Industrial research (CSIR), and Senior Lecturer, University of the Witwatersrand
- Richard Klein, Associate Lecturer, University of the Witwatersrand

Advisory Board

- Bubacarr Bah, Research Chair, African Institute for Mathematical Sciences
- Bonolo Mathibela, Research Scientist, IBM Research Africa
- Ben Herbst, Professor, Stellenbosch University
- George Konidaris, Assistant Professor, Brown University
- Nando de Freitas, Senior Staff Research Scientist, DeepMind

Appendix C: List of 2017 Sponsors

Appendix D: List of African Research Institutions and Academic Researchers

These tables list the African research institutions, and where possible researchers who lead efforts, and are points of contact for machine learning, artificial intelligence and data science at their institutions.

South African Institutions

African Institute for Mathematical Sciences	Dr. Bubacarr Bah	Dr Simukai Utete
	Dr. Yabebal Fantaye	Proff Jeff Sanders
	Dr DC IKpe	Bruce Bassett
	Michelle Lochner	Yabebal Tadesse
	Dr Simukai Utete	Jeff Sanders
Cape Peninsula University of Technology	Prof Izak van Zyl	
Centre for High Performance Computing	Werner Janse Van Rensburg	
Council for Scientific and Industrial Research	Dr Benjamin Rosman	Dr Vukosi Marivate
	Nyalleng Moorosi	Herman Le Roux
	ONNO UBBINK	Dan Withey
	Dr Micheal Burke	Prof. Fred Nicolls
	Tino Museba	
Durban University of Technology	Aboubayda Shabat	
University of Fort Hare	Professor Marlien Herselman	Prof. Khulumani Sibanda
	Dr S.Z Shibeshi	Mr. MS Scott
Hartebeesthoek Radio Astronomy Observatory		
Inter-University Institute for Data Intensive Astronomy	Prof Russ Taylor	
iThemba LABS	Dr. Mlungisi Nkosi	J Gonsalves
Nelson Mandela Metropolitan University	Dr MC du Plessis	Professor Charmain Cilliers
	Prof Igor Litvine	Mr June Simakani
	Prof. JF van Niekerk	
North-West University	Prof Albert Helberg	Dr. Roald Eiselen
	Prof Phillip Mashele	
University of Pretoria	Prof Jan Eloff	Prof. Sergei Rakitianski
	Dr. Jean-Baptiste Ramond	Julia Tshimungu
	Prof Stephan Heyns	Adam Sachs
	Vreda pieterse	Eben Mare

	Prof Andries Engelbrecht	Dr Michael Burke
	Professor Stephan Heyns	Prof. Sonali Das
	Siyabonga Mjali	Dr Alta de Waal
	Dr Inger Fabris-Rotelli	Mr. Christoph Stallmann
	Dr. I Fabris-Rotelli	Dr. H.F. Strydom
	Dr Marde Helbig	
Rhodes University	Dr Arun Aniyan	Oleg Smirnov
	Professor Barry Irwin	K. Bradshaw
Stellenbosch University	Prof. Juliet R.C. Pulliam	Prof. Ben Herbst
	Dr. Hugo Touchette	Dr. Willie Brink
	Prof. Adriaan van Niekerk	Dr. Corne van Daalen
	Professor Johan du Preez	Professor Ingrid Rewitzky
	Jaco Geldenhuys	Dr. Steve Kroon
	Dr. Gaston Mazandu Kuzamunu	Prof Thomas Niesler
	Prof. J.A.C. Weideman	Stephen Burgess
	Dr N Hale	Prof JH van Vuuren
	Dr Johann Strauss	Dr Arnold Rix
	Prof Ronnie Becker	Dr. Corne van Daalen
	Dr Hanno Coetzer	Prof Thomas Niesler
	Professor Ingrid Rewitzky	Brink van der Merwe
	Francois Smit	HA Engelbrecht
	Wouter Bam	Prof. AB van der Merwe
	Dr S. Bierman	Dr Lidia Auret
The University of the Witwatersrand	Dr. Benjamin Rosman	Dr. Richard Klein
	Prof. David Rubin	Prof Montaz Ali
	Dr Terence Van Zyl	Prof. Michael Sears
	Prof. Alex Quandt	Nothabo Ndebele
	Prof. Turgay Celik	Dr Zane Lombard
	Prof. Sergio Colafrancesco	Prof Stephen Jurisich
	Dr. Vukosi Marivate	Prof. Bruce Mellado
	Dr. Terence van Zyl	Dr Mpho Raborife
	Dr O. Nyandoro	Prof. Daniel Joubert
	Prof Ekow J. Otoo	Alan Cornell
	Hima Vadapalli	Dr Clint Van Alten
	Dr. Ken J Nixon	Prof Anton Van Wyk
	Prof Y Zelenyuk	Kevin Goldstein
	Prof. Joel Moitsheki	Dr Benjamin Rosman
	Prof. Ebrahim Momoniat	Prof Sigrid Ewert
	Prof. Raseelo Moitsheki	Vered Aharonson
	Prof. Sigrid Ewert	Prof. Estelle Trengove
	Prof. Ken Nixon	Prof. Bruce Mellado
	Turgay Celik	Dr. Terrence Van Zyl
	Professor Yevhen Zelenyuk	Prof. Charis Harley

	Dr Sameerah Jamal	
University of Cape Town	Joe Eyermann	Joseph Raimondo
	Dr Melusi Mavuso	Prof. Deshen Moodley
	Prof. Andre Peshier	Dr. Brian DeRenzi
	Prof Daya Reddy	Patrick Marias
	Assoc Prof. Deshendran Moodley	Prof. Patrick Woudt
	Robyn Verrinder and Edward Boje	Miguel Lacerda
	Mario Santos	Prof. Heribert Weigert
	Dr. Maria Keet	Professor Thomas Meyer
	Prof. Russ Taylor	Russel Taylor
	Dr. Babatunde Joseph Abiodun	Dr Simon Winberg
	Dr Yannick Libert	Gregory Fried
	Prof. Nicola Mulder	Etienne Pienaar
	Russ Taylor, Kurt van der Heyden	Jonathan Shock
	Prof Sugnet Lubbe	Alvaro de la Cruz-Dombriz
	Mattia Vaccari	A/Prof Mqhele Dlodlo
	Prof. Thomas Meyer	Fred Nicolls
	Dr Bradley Frank	
University of Johannesburg	Dr. Wai Sze Leung	Dr Duncan Coulter
	Mr. P. Robinson	Stephen O. Ekolu
	Prof F Tregenna	Prof Saurabh Sinha
	Dr Deon Sabatta	Dr Yuko Roodt
University of Kwazulu Natal	Prof. Jules-Raymond Tapamo	Prof Serestina Viriri
	Prof Francesco Petruccione	Mattia Vaccari
	Mr Anban Pillay	Prof P. Sibanda
	Prof Nelishia Pillay	Prof Jonathan Sievers
	Prof. Randhir Rawatlal	Dr. Tahmid Quazi
	Prof B McArthur	Prof. Aderemi O. Adewumi
	Prof. Francesco Petruccione	Anban Pillay
	Dr M Mariola	
University of Limpopo	Dr Modipa T	
University of venda	Professor Winston Garira	
University of the Western Cape	Dr Mathis Wiedeking	Prof. Mario Santos
	Professor Michelle Cluver	Prof. Roy Maartens
Vaal University of Technology	Dr Mpho Raborife	Prof. Sigrid Ewert
Walter Sisulu University	Chrispin Kabuya	Mr Simbarashe Nyika
University of the Free State	Prof. Pieter Blignaut	Dr. Eduan Kotzé
University of South Africa	Dr Antoine Bagula	Prof Laurette Pretorius
	J.D. Botha	Mphahlele Thaba
	Prof Sonja Bosch	Prof Themba Dube
	Dr Sheryl Buckley	
Tshwane university of Technology	Josiah L Munda	Rosinah mathepe Matsimbi

		Prof. Thomas Olwal	PROF. Y. HAMAM
		Prof. A. A. Jimoh	
South African Biodiversity Institute (SANBI)		Melanie Lück-Vogel	
South African Astronomical Observatory		Dr Encarni Romero Colmenero	Bruce Bassett
Square Kilometer Array - South Africa		Nadeem Oozeer	

African research institutions outside the host country (South Africa)

Botswana	University of Botswana	Dr George Anderson	Tshepo K Gobonamang
		Dr Tshiamo Motshegwa	Dr. Edwin Thuma
		Dr. A.N. Masizana	Prof Yirsaw Ayalew
		Prof Narasimhan	
	Botswana International University of Science and Technology	Ontiretse Bagwasi	Dr. B. Basutli
		Dr Hlomani Hlomani	Dimane Mpoeleng, PhD
		Dr Rodrigo S. Jamisola	
Senegal	African Institute for Mathematical Sciences	Dr. Mamadou Moustapha Mbaye	Aaron Smith
		Dr. Amadou Lamine Toure	Papa Ngal Diao
		Prof. Aissa Wade	BOUDOUR Mohamed
		Ibra DIOUM	Cheikh Loucoubar
		Des Johnston	Prof. Farai Nyabadza
		Abdourahmane THIW	Prof.Tabea Rebafka
Kenya	University of nairobi	Dr.Collins Mito	
Madagascar	University of Antananarivo	Dr Hanitriarivo Rakotoson	Hery Zo Randrianandraina
		Minoson Rakotomalala	Pr. Roland RABOANARY
Lesotho	Limkokwing University of Creative Technology		
Egypt	Cairo University	Mona Farouk	
	Nile University	Prof. Dr. Samhaa El-Beltagy	
Mauritius	University of Mauritius	Dr. S.Z Sayed Hassen	
Morocco	Chouaib Doukkali University	Hamid Zouaki	
NIGERIA	NATIONAL OPEN UNIVERSITY, NIGERIA		
Ghana	Kwame Nkrumah University of Science and Technology	Dr. Alexander Kwarteng	Dr. Firempong

		Dr. Victor Kootin-Sanwu	Dr. Peter Amoako-Yirenkyi
	University of Ghana	Dr. Emmanuel Ampomah-Amoako	
	Ghana Space Science and Technology Institute	Dr. Bernard Duah Asabere	
Namibia	Namibian University of Science and Technology	Guy Alan Zodi	
Cameroon	AIMS-Cameroon	Ralf Wunderlich	
Sudan	University of Khartoum	Dr. Iman Abuel Maaly Abdelrahman.	Prof. Sharief.F.Babikr
Tanzania	Dodoma university		
	The Nelson Mandela African Institution of Science and Technology (NM-AIST)	Prof Nerey Mvungi	Prof Eugene Park
	University of Dar Es Salaam	Dr Joseph s Kiani	Dr. Shubi Kaijage
		Dr. Zaipuna O. Yonah	
Zimbabwe	University of Zimbabwe	Dr Gilford Hapanyengwi	
	National University of Science and Technology		
Zambia	University Of Zambia		