Education and Public Outreach activities in Radio astronomy with the SKA South Africa.

N Oozeer\textsuperscript{1,2,3}, B A Bassett\textsuperscript{2,4,5}, K de Boer\textsuperscript{1}
\textsuperscript{1}SKA South Africa, The Park, Park Road, Pinelands, Cape Town 7405, South Africa.
\textsuperscript{2}African Institute for Mathematical Sciences, 6-8 Melrose Road, Muizenberg 7945, South Africa.
\textsuperscript{3}Centre for Space Research, North-West University, Potchefstroom 2520, South Africa.
\textsuperscript{4}Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, Cape Town, 7700, South Africa.
\textsuperscript{5}South African Astronomical Observatory, Observatory Road, Observatory, Cape Town, 7935, South Africa.

E-mail: nadeem@ska.ac.za

Abstract. A Human Capital Development (HCD) program is a crucial part of any large organisation, and especially for large new research facilities such as the Square Kilometre Array (SKA) Africa. HCD provides a way of developing and channeling new minds into a very demanding field that ensures sustainability of the project and a multitude of spin-off benefits. Apart from educating learners at various levels, the HCD program must also inspire and educate the general public about the projects via an active outreach program. We highlight the various types of outreach activities that have been carried out in South Africa and the other SKA Africa partner countries. While there exist many teaching models we introduce and explore a novel concept of peer teaching for research known as the Joint Exchange Development Initiative (JEDI) and present some of its results. The JEDI workshops have resulted in a considerable number of learners embarking on advanced careers in science and research, and the demand is still growing.

1. Introduction

Outreach is a very important activity for an organisation especially for new upcoming facilities such as the Square Kilometre Array (SKA) Africa. Outreach is not only always about explaining a particular project but also at times it can be useful to channel more learners into science education, especially in Africa. There has been significant development in astronomy, in Africa (particularly in South Africa), in the past decades. The Southern African Large Telescope (SALT) and the High Energy Stereoscopic System (HESS) have been constructed and commissioned, in South Africa, and in Namibia respectively. South Africa is currently constructing the 64-antenna array radio telescope, MeerKAT, which will be incorporated into phase 1 of the SKA. In addition, nine other countries in Africa are participating in the SKA project, as well as the African Very Long Baseline Interferometer Network (AVN). These instruments prompt for a demand of skills and professional such as technicians, engineers and scientists have caused a huge quest for brain-gain and urge students to opt for science and engineering.
There are various ways of going through outreach in astronomy, science and other fields. For example it is very easy to put in a telescope and ask the learners to have a star gazing party. It is also very attractive to show colourful optical celestial images, but showing radio contours and false colour pictures of radio sources is not so attractive. It is not very straightforward when has to do outreach in radio astronomy and talking to learners and the general public about it. Lack of visual memory can affect remembering and consequently learning in many people. The fact that nowadays majority of the learners know and have access to huge amount of information, this can help us to do radio astronomy outreach effectively.

This paper is divided as follows: §2 discusses the various types of outreach activities that have been carried out in South Africa and §3 describes the Joint Exchange Development Initiative (JEDI), that is one of the education human capital development (HCD) programme that we have implemented. We finally conclude the paper in §4.

2. Outreach overview
Before going into detail about radio astronomy outreach, we shall try to review some of the key points generally taken into account during outreach events. A question we always ask is what do we want to convey during outreach. We are already submerged by so much of information nowadays so why will people still want to hear about us. Many will agree that knowing the audience is a key point for efficient outreach. We can classify the target audience for outreach as easily reachable and hard-to-reach. Sandu et al. (2011) [1] mention, how can we grab the attention of all those targets that have not yet been converted, especially the hard-to-reach.

Timing is very crucial while going for outreach. It might not be wise to do outreach to students during the pre-examination period for they will never want to listen. On the other hand, catching students when they will be making their subject choices can be very effective. An important role in outreach is to trigger the wow factor and get the learners interested and also leaving them with this awe that will make them quest for more.

2.1. Onsite visit
Onsite visits consist of going to various schools, community centres, and science festivals to talk about our project. During these visits, talks and presentation are the best way to reach the audience. However, this also involves a mixed crowd and one shall be careful as it can have a negative impact if one is not well prepared and can kill the essence of outreach. It is advisable to rework ones outreach methodology according to the crowd. Animated presentations with little or no scientific equations does help a lot for general public. Posters/banners are very useful to attract attention if they are very colourful and nicely presented. Freebies always attract lots of people to a stand for example, but the quality and quantity can leave many people unhappy.

2.2. Mass media
Mass communication is another aspect of outreach. We can reach a huge number of people in a very short time span. However, mass media has evolved drastically since the last decades. We are moving towards a computerised electronic communication that has its advantages as long as the target group has access to such technology. Talks on the radio tend to attract elderly groups while career related television shows have more impact on the younger generation.

2.2.1. Audio/Video
Audiovisual has always been the privileged way to communicate to the mass. However, it is quite difficult to ensure that all the audience has got the right information. One key point is to make small series of a programme, each time explaining a small portion of a project. Nowadays with social media and the Internet, lot of outreach activities can be done using these media. There exist many other outreach activities similar to the one we are
doing. Using these outreach materials into ones (acknowledging the various authors) event allows strengthening the outreach materials and also show the diversity of similar projects. A project web or wiki page written in diverse languages allow a good flow of information from the source to the mass. However, designing of a good web page is also very essential in order not to make the Internet users lost in a sea of information.

2.2.2. Printed media
Printed media such as; newsletter, newspaper, flyers are still very useful to reach a different crowd. Even though we have moved into an electronic version of all these form of media, in developing countries there are lots of places where there still exist no Internet facilities or audio/visual equipment. In these places, printed materials coupled with hands on activities have shown to be very useful. The SKA Africa came up with the Mission MeerKAT cartoon to explain the SKA project. This project has reached a huge crowd and when one re-visits a place for outreach, very often the learners who heard of these cartoons would want their own copy while others are eager to get the next volume. Starting with the concept of explaining what is the SKA Africa project, this has evolved into a more pedagogical tool to teach students about other SKA partner countries, from the extinct dodo of Mauritius to national animals of these countries and the various instruments to be used in the partner countries.

2.3. Artistic approach
Artistic shows and performances can be used to bridge the gap between culture and science. Archeo-astronomy, the study of how various civilisations perceive the sky and the Universe is now more frequently discussed and form an interesting field of research. From the Australian aborigine view of how the Milky Way [2], was created by the emu to the seven sisters/princesses in African folk stories [3] to talk about the Pleiades, astronomy has been well been used by the ancients. It is an innovative way to awaken people imagination about various scientific issues. However one has to be very careful not to touch the sensitivity of one belief and cultures.

2.4. Radio astronomy outreach
It can sound very complicated when one start talking about signals, filters, amplifier and other technical terms. One starting point for radio astronomy is to use the “Eye and I” concept. The human eye collects visible light and the lens brings the light to the retina where it will be digitised and transferred to the brain. The “I” concept questions the target audience about what they are already know and use in their everyday life and then bring it to another level.

In brief, a radio telescope consists of various parts. The dish that captures the signal coming from outer space, reflects it to a sub-reflector, converts the signal into electrical signals that is then transmitted to the computing system where the signal is further analysed. A digital satellite dish can be used to teach radio astronomy at various levels. The output from the receiver of a satellite dish can be connected to a satellite finder, which has an output to a speaker. The output can also be connected to the microphone input of a computer running specific software and can now be recorded, listened to and displayed. The students can see the radio signal. Similarly the same dish can be used to measure signal from various sources and detect radio frequency interferences (RFIs).

3. Education with JEDI
In education, the curriculum provides a plan sets for learning, while the instruction is the actual engagement of the learners with planned learning opportunities. The teaching is a process whereby one mediates between another person and the materials. There exists many teaching models from lectures, discussion, questioning, to independent learning and self-teaching. The Joint Exchange Development Initiative (JEDI - http://jedi.sao.ac.za) is a way to maximise on the teaching methodologies.
The JEDI is a concept to enhance development and education via direct transfer of skills and expertise in any specific field. It is an initiative to provide development via joint exchange among stakeholders. This is achieved by bringing stakeholders: students, post-docs and staffs together in an informal but intense research environment to tackle unsolved problems for e.g. in Astronomy. [BB] introduced the concept in South Africa and since then various models/variants have been tried and tested depending on the need and requirements of the participants. From these interactions, scientific publications [4, 5, 6, 7, 8] have been produced and stronger collaborations have been created. The JEDI concept is based on the following insights about research and learning:

- It is well known that true learning occurs when students actively engage with material. Listening is not active engagement. Hence most conference talks do not provide real learning environments. Research success requires skills in the most relevant topics and toolsets. In the 3rd world, supervisors are often out of date in terms of the topics they research and the tools they use.
- Conferences advertise the result of years of research; they do not teach participants how to do research. It is the lack of examples and role models of how to do good research that is most critically absent and most desperately needed in the third world.
- Ability to work in teams is critical to modern research success. Yet many undergraduate and graduate programs, especially in third world countries, are mired in education approaches based on individual work. Most students lack the interpersonal skills to work and communicate effectively in teams.

The JEDI model address all three of these major issues at one stroke. It is based on active engagement of real research projects with other students and faculty. It fosters friendships, teamwork and community between the students and with the faculty which all persist years after a workshop. The six JEDI workshops that have been held have shown just how successfully this is achieved. These successful models are now replicated to other African countries (Mauritius, Kenya, Namibia, etc.), especially in the future era of huge datasets with the SKA.

4. Conclusion
In this paper we have reviewed some of the outreach activities that we have initiated and continuing with the SKA Africa. It is a way of channeling new brains into a will be demanding area. Such feeder will eventually sustain the project. We also presented the novel method of peer teaching through the JEDI. These activities are producing their fruits with more and more students are moving into science and engineering. These activities are undoubtedly producing new generation Astronomers and Engineers for the upcoming SKA Africa.

5. Acknowledgments
NO would like to acknowledge assistance, support and encouragement from the SKA Africa colleagues who have contributed enormously in various activities related to this work.

References
[1] Sandu O. and Christensen L. L., Outrageous outreach, CAP Journal, July, 2011.
[2] Norris, R. P., & Hamacher, D. W. 2011, IAU Symposium, 260, 39
[3] Lloyd Bleek Collection, University of Cape Town (2007), http://lloydbleekcollection.cs.uct.ac.za
[4] Bassett, B. A., Brownstone, M., Cardoso, A., et al. 2008, JCAP, 7, 7
[5] Crawford, S. M., Ratsimbazafy, A. L., Cress, C. M., et al. 2010, MNRAS, 406, 2569
[6] Newling, J., Varughese, M., Bassett, B., et al. 2011, MNRAS, 414, 1987
[7] Kessler, R., Bassett, B., Belov, P., et al. 2010, PASP, 122, 1415
[8] Zwart, J. T. L., Jarvis, M. J., Deane, R. P., et al. 2014, MNRAS, 439, 1459