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To: UCITE Nord Grant Committee

In the past year, Lacks and Sankaran have developed programs to train undergraduate students in science and engineering with a perspective of the life, culture and constraints of sub-Saharan Africa. Pedagogically, these programs build on experiential learning theories put forth by Kolb and others. Our programs last year alone included 41 CWRU students in 3 very different types of courses – an engineering core course, a capstone design course, and a SAGES seminar. In addition, our undergraduate research training programs last year in Africa involved 7 students from 4 universities. The programs are financially self-sustaining, through fees paid by the students or grants from the National Science Foundation. We believe these programs are exciting, unique and innovative, and can help CWRU 'stand out' among peer institutions.

We plan to continue and expand these programs – we believe we can fill a niche and CWRU can become a national leader in these types of programs. The key to making these programs succeed is our having expertise in science and engineering practices in Africa. We have an opportunity to extend our expertise this Fall with a visit the University of Dakar, the leading university in West Africa.

Description of our programs thus far developed

i. Undergraduate CWRU engineering core course taught at the University of Botswana in 3-week session. We developed a novel course (ENGR 225B), which we taught at the University of Botswana in a 3-week session in May 2011 – 21 students took the course. Our course is a special offering of a core course required of all CWRU engineering students, which covers thermodynamics, fluid flow and heat transfer. is a very rigorous course with well-defined course content. Our course intertwines technical content with regional issues in sub-Saharan Africa – by holding the course in Botswana, students are able to experience the connections between technical content and regional issues. For example, energy balances for flowing fluids are addressed in the context of pumping water from wells in villages in the Kalahari Desert – how much energy is required to pump the water, what is the cost of the necessary fuel, and how does this fit in the village's economic budget? A field trip to a Botswana village to see such wells and pumps, guided by an engineer from the Botswana Water Authority, showed firsthand how fluid flow issues intersect with village life. Other examples include a visit to the world's richest diamond mine in conjunction with the study of the thermodynamics of phase transitions, and a study of the 'passive air-conditioning' in African mud huts. We have written an article about the experiential learning aspects of this course, which has been submitted to the journal *Chemical Engineering Education*.

ii. Capstone design project in Botswana. Lacks developed a new chemical engineering capstone design course (required of all chemical engineering seniors) in which students work in 3-person groups on 'real-life' projects and interact with experts outside the university. Usually, these projects are carried out in conjunction with local companies. But this past year, one group investigated alternative energy solutions for remote African villages that are far from the national electrical grid (85% of rural Botswana households do not have electricity). The group of 3 students travelled to Botswana (with Lacks and Sankaran) in November 2010 to see such villages and discuss the issues with engineers from the Botswana Power Company and faculty at the University of Botswana, in order to determine the economic, societal, ecological and institutional factors that will affect their plans. The students focused on the design of a biogas reactor to generate methane from cow dung, and they built a working lab-scale prototype.

iii. SAGES Seminar course on 'Education in sub-Saharan Africa'. In the Spring 2011 semester, Lacks and Sankaran hosted the sabbatical visit of Dr. Rufus Akande, a faculty member in the Department of Physics at the University of Botswana. Lacks and Dr. Akande co-taught a Sages seminar course entitled 'Education in sub-Saharan Africa' – Dr. Akande provides a great perspective on this subject, as he has over 30 years of experience teaching in universities and secondary schools in Botswana and Nigeria. There were 17 students enrolled in the course.

iv. Undergraduate Research Training Program at the University of Botswana in 'Research in Sustainable Energy for sub-Saharan Africa'. We run a research training program for undergraduate students from the US and Botswana – note that the goal of the program is training students in research with a global perspective (rather than the research

itself). The program takes place at the University of Botswana, and includes laboratory research and professional development activities (giving presentations, writing scientific papers, etc.). The theme of the program is sustainable energy relevant to desert environments, such as solar energy and biofuels. This program is funded at $150,000 for 3 years by the National Science Foundation, beginning May 2011. We ran our first installment of this program this May – due to the late arrival of funds we ran a small version of the program with 2 US students and 3 Botswana students. In future years we will have 7 US and 7 Botswana students in the program.

v. *Undergraduate research on dust storms in Niger*. We included two undergraduate students from the University of Niamey (Niger) in our field studies on the electrification of dust storms carried out in Niger in June 2010. This was the first time these students experienced research in any way (in fact, they even have very little laboratory course work in their curriculum due to the high costs of operating laboratory courses).

The purpose of this Nord Grant request

The key to making these programs succeed is our having expertise in science and engineering practices in Africa, and connections with universities in Africa. We have the opportunity to extend our expertise this Fall with a visit the University of Dakar, the leading university in West Africa. In particular, we will focus on learning more about sustainable energy and clean water practices in Africa, so that we can incorporate this into our courses and training programs.

The plan is for Lacks and Sankaran, along with our postdoctoral associate, Dr. Mamadou Sow, to spend 4 days in Senegal. Dr. Sow is originally from Senegal and has the connections in place to ensure a fruitful visit. Through Dr. Sow, we have been in contact with Prof. Amadou Gaye, Head of the Laboratoire de Physique de l'Atmosphere et de l'Ocean (LPAOSF) at the University of Dakar. Prof. Gaye has offered to host our visit. We will meet with faculty and tour laboratories from various departments related to our activities. We will use this opportunity to learn more how science and engineering intersect with life in Africa, in order for us to improve our educational programs described above. We will seek to develop educational collaborations. We will also meet with administrators to discuss possible collaborations, including academic Deans, research administration officers, and international program officers.

Leveraging of funds

We are requesting only $2000 in this Nord proposal, as we have the remaining funds needed from other sources. Note that this is only a tiny fraction of the costs involved in developing and running these programs. Other costs thus far have come from the following sources: National Science Foundation grants ($15,000, $10,000 and $150,000), previous Nord grant ($2500), Case School of Engineering ($2000), Department of Chemical Engineering ($1500), student payments for ENGR 225B ($3100 tuition + $650 room/board + ~$1600 travel per student x 21 students ≈ $112,000), student payments for capstone design course (~$1500 per student x 3 students ≈ $4,500)

While we received a $2500 Nord grant last year, we believe our successful activities resulting from this grant and the large number of students impacted (described above) justifies the request for further funding (note both this request an the previous have been for relatively small amounts of money).

Sincerely,

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R. Mohan Sankaran
Associate Professor
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Uziel Landau
Professor and Chair
Dept. of Chemical Engineering

Budget:

We request funds for Lacks, Sankaran and Dr. Sow to travel to the University of Dakar (Senegal). We are requesting here $2000, with the remaining costs being covered by other sources. The $2000 will cover the flight ($1500) and hotel ($100/night) for one person.