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Research Funding Needs for African Engineers: Challenges and Perceptions

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Abstract Africa and sub-Saharan Africa in particular, with the exception of South Africa, have lately lagged behind in postgraduate research, an issue attributed to lack of research funding for engineering sciences. This paper investigated the funding needs of engineering sciences in Africa. Specifically, it established the funding needs of African engineering sciences, factors affecting higher learning institutions in securing research funding and assessed the prevalent engineering research needs for Africa. Key informants to this paper were postdoctoral candidates drawn from Cameroon, Ethiopia, Ivory Coast, Kenya, Nigeria, Tanzania, Uganda and Zimbabwe. Through a questionnaire survey, the study found out that Africa has the capacity to carry out high profile engineering researches but the funding needs are not fully met resulting in frustration, whose ripple effects culminate in brain drain. Institutional frameworks in many African countries have been found not favouring engineering sciences. Although efforts are being made, as evidenced by increase in scientific publications, the growth of Engineering Sciences lags behind other disciplines. Thus, the international community of research funders should forge partnerships and collaborations with engineering institutions in Africa for availing and putting to good use research funding.

Keywords: *African engineers, engineering sciences, postdoctoral research, sub-saharan Africa*

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1. Introduction

Higher education in Africa is not spared by a myriad of growth and development challenges being faced by other continents [1]. However, research in engineering sciences can play a vital role in mitigating economic and developmental handicaps of Africa. This is because engineering research can bring about technological innovations that can improve living standards and general life expectancy [2].

Research output from sub-Saharan Africa (SSA) is less than 1% of the global research output despite having 12% of global population [3]. Although advances in health sciences are contributing 45% of research output, Engineering and Technology contribute only 15%. The research contribution of engineering and technology has marginally declined by 2% since 2002, suggesting that the disciplines have been facing challenges that hamper their progress [4]. Global research funding is argued to be insufficient to meet all research needs [5]. The developing world suffers from a widespread disparity in eminence of research capacity [5]. A case of Nigeria, which is the largest economy in Africa, has more than 10,000 academic staff in public universities, but less than 50% of them has a PhD course [6].

Research collaboration (both North-South and South-South) is an important means of building research capacity and generating relevant knowledge. Inter-regional collaborations in Africa have not borne positive results. Between 0.9% and 2.9% inter-regional collaboration and inter-African collaboration (except for South African) comprises 2% of all East African research, 0.9% of West and Central Africa, and 2.9% of Southern Africa [3]. The Compound Annual Growth Rate (CAGR) for Southern Africa stands at 8.5% while for West and Central Africa it is at 12.7% [3].

Lack of funding and the enabling environment have been cited as some of the key challenges faced by engineering sciences in SSA [4]. These problems are increased by the degradation of the engineering research infrastructure due to inadequate investment over many years [2]. Engineering sciences in SSA, except for South Africa, have not developed the same way as other academic courses and as such it would be of paramount importance to explore the challenges that African engineers face in acquiring research funding. Understanding such challenges enables funding organizations to provide the necessary interventions that would enhance research in engineering sciences. This paper equips engineering researchers with options and opportunities at their disposal. It analyses the challenges experienced by engineers in Sub-Saharan Africa in accessing research funding. Specifically, the paper seeks to characterize engineering funding needs for researchers in SSA, identifies existing funding options for postdoctoral researchers and explores the research funding challenges, perceptions and perspectives for SSA.

2. Research Methodology

A questionnaire was applied to a sample of 15 postdoctoral (Engineering Sciences) candidates. These were drawn from sub-Saharan Africa during a postdoctoral fellow selection conference held in Kenya in June 2015. The research findings were analysed using descriptive statistics, presented in tables and charts.

3. Results and Discussion

3.1. Institutions from which African Faculties Obtain Their Doctoral Degrees

This paper also sought to establish the sources and distribution of doctoral studies within African university faculties. The sources of doctoral degrees for African engineers are shown in Table 1.

Table 1. Major source of doctoral degrees for African engineers

Place of graduation	Percentage Average
Same faculty	33.0
Same country	22.5
Within Africa	13
America	16.0
Asia	22.0
Europe	48.0
Australia	8.0
New Zealand	8.0
Canada	7.0

The largest number (48%) of African engineers obtained their doctoral degrees in Europe with UK alone contributing 15%. African universities contribute only 13% of doctoral degrees in Engineering Sciences. 16% of doctoral degrees by African nationals are from America. This is because in America foreign nationals comprise more than 40% of graduate enrolments in physical sciences, mathematics and computer science, and engineering [2].

3.2. Success Rate in Attracting Research Funding

When researchers apply for funding, they either succeed or fail due to the competitiveness of the calls for funding. The probability of success in securing research funding at each level is shown in Table 2. There is 35% success probability that one gets a postdoctoral research funding in Engineering Sciences, if one applies meeting all minimum requirements.

Table 2. Success rates in attracting study/research funding

Level	Success probability
Undergraduate	70%
Graduate	25%
Doctoral	55%
Postdoctoral	35%
Other researches	36%

3.3. Transitioning from One Academic Level to Another

The average time taken by a student/researcher before being admitted to a given academic level is shown in Table 3. It takes about 1.25 years after high school in Africa before getting an undergraduate place to study engineering related courses. On the other hand, it takes 2.31 years after graduate school for one to initiate doctoral studies.

Table 3. Average time to transition from one academic level to another

Level	Undergraduate	Graduate	Doctoral	Other
Years	1.25	3.25	2.31	2.00

3.4. The Capacity of African Engineering Research Centres to Conduct Doctoral and Postdoctoral Research

It was unanimously agreed by all respondents that Africa has the capacity to carry out both doctoral and postdoctoral research. However, 7% respondents indicated that although the capacity is there, some African countries and other engineering research centres have no capacity to carry out both doctoral and postdoctoral studies. It is believed that poor African countries lack research capacity in fields like Medicine, Mechatronics, Space Engineering, Robotics etc., and may not be carried out in African countries due to the technical complexities associated with the academic courses [3]. Other countries, on another hand, do not have the facilities as well as technical staff to carry out certain specialised researches.

3.5. The Increase of Publications in Engineering Departments between 2005 and 2015

From the 15 institutions of higher learning represented, there has been an increase of 44.4% in publications since 2005 (i.e. over the past ten years). World Bank [3] indicated that in engineering sciences, publications have increased by 8.5% Compound Annual Gross Research (CAGR), which is rather below expectation. However, with the advancement in technology, opening of new institutions of higher learning and the enabling environment, a greater number of publications are expected.

All SSA regions more than doubled their yearly research output for the period 2003-2012 [3]. And between 7.5% and 16% of the total outputs were amongst the world's top 10% most highly cited articles, but only 5.9% -10% of the total output in the Physical Sciences and Science, Technology, Engineering and Mathematics (STEM) met that threshold [3].

3.6. Sectorial Funding Priorities in Engineering Sciences

The funders' priorities for research in engineering sciences are ranked in Figure 1. Renewable energy related researches are receiving the highest priority followed by

agriculture and food security. Health and life sciences were least prioritized at postdoctoral level. However, it was pointed out that health and life sciences attracted hugest collaboration grants.

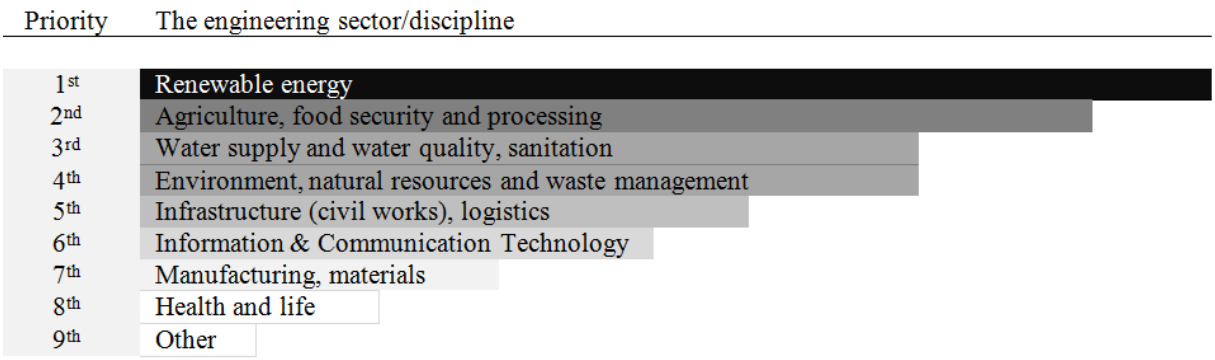

Figure 1. Funding priorities by engineering sector/discipline

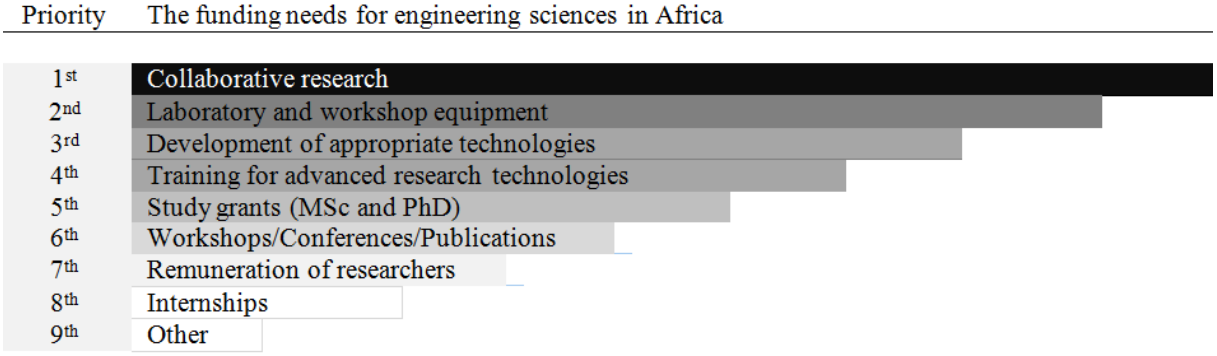

Figure 2. Prioritised funding needs for engineering sciences in Africa

The DFID research funding framework 2005-2007 prioritized four research themes: sustainable agriculture, killer diseases, states that do not work for the poor and climate change [5]. However, African engineering sciences have their peculiar funding needs and priorities. Funding for collaborative research is top priority, while funding for internships is least prioritized, (Figure 2).

The funding needs of engineering sciences in Africa as a priority percentage for each academic/professional level are shown in Table 4.

Table 4. Academic/professional funding levels

Level	Average
Undergraduate	30%
Graduate	18%
Doctoral	32%
Postdoctoral	20%

Thus, from the results, more funding should be directed towards doctoral and undergraduate studies. It was also highlighted that with an increase in funding for doctoral studies, the capacity to generate more meaningful, adaptable and appropriate researches for Africa will be enhanced.

3.7. Funding Agents for Engineering Sciences in Africa

Basing on the experiences of the key informants, Table 5 shows the most active funding organisations supporting engineering sciences in Africa. From Table 5 the governments in sub-Saharan Africa are the major funders of undergraduate studies, while international funding organisations fund most of the postdoctoral research.

Table 5. Sources of funding for different academic levels

Undergraduate	Graduate
• Government scholarships • Government loans • Self-sponsorship • Bursaries	• Private and public Fellowships • Universities/staff development • Research foundations
Doctoral	**Postdoctoral**
• Research Projects externally funded • University scholarships • Research councils	• International foundations for sciences • International funding agencies

It can be noted that some of the programmes that have not been documented such as the Water and Sanitation Programme and the Water Supply and Sanitation Collaborative Council promote best practice but do not have the necessary resources to finance or coordinate research [5]. In sub-Saharan Africa, Waternet, Swiss Centre for Research, CIGAIR, and CYMMIT have lately provided much needed research funding support in water, sanitation, hygiene and agriculture.

3.8. Existing Funding Options for Postdoctoral Studies

Many African engineers have opted to do their postdoctoral studies in foreign countries especially the developed countries. The percentage preferences by geographical location are shown in Table 6. There are many reasons to

such widespread options. Some of the reasons include availability of postdoctoral fellowships, advancement in technology, and personal preferences among other things.

Table 6. Worldwide distribution of engineering fellowships

Geographical distribution	Percentage Average
America	21.0
Europe	31.0
Africa	9.0
Asia	12.0
Australia	6.3
Canada	8.5
New Zealand	5.0
UK	11.4

Many African scientists have undertaken and or find more opportunities for postdoctoral studies most in Europe, America, Asia, UK, South Africa, Canada and least in Australia, respectively (UK was singled out of Europe because of its significant contribution) (Table 6). This could be because capacity building requires substantive and long-term investment, of which many developing countries cannot afford [5]. Thus, from such findings, it can be inferred that if no proper funding mechanisms are available, Africa will take long to develop its own home grown solutions from engineering sciences due to the impacts of brain drain. Although efforts by many funding agencies to have postdoctoral fellows being attached to their African institutions, many fellows end up absorbed by their host institutions. Between 1960 and 1987, Africa lost a third of its professionals to the developed countries [7]. An estimated 23,000 academics and 50,000 middle and senior management personnel leave the continent each year; and more than 40,000 Africans, each with a PhD now live outside the continent [8].

3.9. Africa's Main Research Collaborating Partner Institutions

African institutions of higher learning have made partnerships with institutions from the developed world as a way of tapping into the expertise in those institutions. However, even among themselves, African universities and other research institutions have partnered. The notable examples of facilities in Africa for collaborative research and development are: African Laser Centre in South Africa, African Research Centre in Senegal, African Regional Centre for Engineering Design and Manufacturing in Nigeria and the African Institute for Higher Technical Training and Research in Kenya [4]. These highly resources institutions could be used for furthering the capacity of African Engineers.

3.10. Collaborations and Partnership for engineering Sciences in Africa

If African research institutions can partner with institutions of higher learning they can gain access to greater resources and thus create lower cost technologies [9,10]. The different types of collaboration and partnerships within Africa and between Africa and the rest of the world are shown in Table 7.

3.11. Rating of Institutional Collaborations of Africa with Other Countries

None of the survey participants highlighted that collaborations are excellent. However, the majority (50%) of the participants concurred that institutional collaborations of Africans and other countries are "good", 25% indicated that collaborations are "poor" while 12.5% said that collaborations are "very poor" and 12.5% indicated that collaborations are very good. Although the descriptors for rating the soundness (goodness) of collaborations by African institutions are subjective, the established ratings still act as a good yardstick to assess the soundness and existence of such collaborations.

3.12. Factors Affecting Access to Engineering Sciences Funding

African institutions of higher learning, on the other hand, fail to attract the much needed research funding for engineering sciences because of inherent institutional set-ups that do not promote attraction of research funding. Some of the challenges and factors are highlighted in Table 8.

Many of these factors and challenges tally well with the challenges about research capacity building in Nigeria as outlined by [6], the Minister of Science and Technology. He cites poor and inadequate infrastructure, lack of funding, lack of enabling environment and brain drain as hampering research capacity building. Furthermore [4] concur with the challenges outlined in Table 8 and indicate that some challenges are not only institutional but other donor countries or funding models employ "tied aid" where the professional capacity and equipment and materials are prescribe by the donor hence little or no skills transfer takes place.

Table 7. Nature of collaborations and partnerships intra and extra-Africa

Collaborations	Partnerships
• Exchange programs between universities	• Joint proposal development
• Sharing laboratories for research purposes	• Joint publication of research results
• Academic faculty and student exchange programs	• Voluntary teaching and advising activities
• Joint courses	• Joint supervision and examination of students
• Collaboration in graduate training	• Equipment and facility sharing
• Joint research and development projects	• Joint resource mobilisation
• Joint PhD training	• Academic mobility between partners
• Joint proposal submission	• External examination of graduate theses and undergraduate students
• Review of funding proposals for other institutions	• Joint regional conferences

Table 8. Factors affecting access to funding

Priority	Factors affecting access to funding
1	Lack of good research facilities at the university. Lack of experts in universities and research institutions (due to low payment and lack of academic freedom).
2	Focus on undergraduate training only. High teaching loads leave little time to develop competitive proposals. High teaching loads reduces lecturers' time for the research activities. Furthermore, the majority of African institution does not have a clear succession plans and hence the new researchers do not have the necessary mentorship.
3	Government policies and institutional framework have not prioritized funding of engineering sciences. There are no meaningful strategic engagement plans.
4	Weak institutional collaboration between relevant stakeholders, especially industry and universities. Funds are not allocated for collaborations but funds are only meant for project operations.
5	Currently, industries in Africa do not have developed research and development departments thus limiting allocation of funding for emerging engineering sciences. Furthermore, there is limited funding for procuring state of the art equipment.
6	Corruption and mismanagement of research funds. Favouritism, especially in projects where funds are managed locally.
7	More attention is paid at importing developed technologies than promoting more research to develop technologies in Africa for Africa.

Table 9. Prioritized approaches and strategies for attracting more funding

Priority	Approaches/strategies
1	Developing collaborations and creating networks. Engaging in joint research grants applications.
2	Developing partnerships: South-South partnerships and public-private partnerships.
3	Increasing awareness of responsible government agencies and policy makers regarding the importance of engineering researches.
4	Being vigilant in responding to calls for funding, possibly establish a grants office to notify staff of calls and submission due dates. Allocating sufficient time for research in line with teaching responsibilities.
5	Improving training on funds mobilisation. Nurturing a research culture through mentorship of graduates.
6	Innovating: Research towards meeting the engineering needs of the continent.

3.13. Approaches and/ or Strategies that could be adopted by African Engineering Institutions to Attract More Funding

African research institutions can adopt several strategies and approaches that can aid them in attracting more funding. The strategies and approaches proposed are outlined in Table 9.

3.14. African Engineering Sciences Funding Expectations in Any Research Funding Agreement

African engineering sciences have many funding expectations. If these expectations are fully met, the demand for research funding will be enhanced and project sustainability will follow. The research funding agreement between the funding agency and the researcher/research institution plays a very important role in project sustainability. This paper discusses budgeting and collaboration clauses important from meaningful engagement as shown in Table 10.

3.15. Proposed Fellowship Duration

The fellowship duration in most of the time is determined by the funding organization. However, in some cases the funding body considers the activity plan of researchers that best fits the proposed project. It was opined that the minimum fellowship duration for engineering sciences should be one year and the maximum be five years. However, the Haldane Principle used in the UK stipulates that decisions on individual research proposals are best taken by researchers themselves through peer review [11]. Shorter duration fellowships are perceived to be good only for networking and appreciation of the facilities held by the host institutions but less meaningful for in-depth research.

Table 10. Inclusions in research and funding agreements

Budgeting
• Budget lines should be adequate to fund all activities of the project • Clear budget lines to avoid confusion • Budget should be flexible to allow for transfer of funds between line items • Budget should fund training of MSc, PhD candidates and teaching assistants • Budget should allow funds to buy equipment • Budget should cater for recurrent expenditure
Collaborations
• Internal and external collaborations should be improved • Inclusion of national, regional and international partners • Agreements should be open to allow for the development of research networks • Improve academic mobility and resource mobilisation • Joint partnerships should be encouraged
Research autonomy
• Researcher should be autonomous, but free to engage relevant stakeholders • Despite autonomy, the research should be demand driven
Publications
• Publications should be requirements in all research grants agreement • Books authorship • Patents
Other inclusions
• Adequate allowances should be made for researchers and advisors to promote more effective researches

4. Conclusion

Despite the challenges faced by engineering sciences in Africa, there exists a huge potential for African engineers to attract research funding. There has been an increase in scientific publications by African Engineers, however, the growth of Engineering Sciences lags behind other disciplines. African research institutions should partner and collaborate with the developed world and among themselves in order to enhance research output. The institutions should also revise their institutional frameworks to accommodate research innovations and funding.

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