ROYAL ACADEMY OF ENGINEERING

AFRICA-UK Engineering for Development Partnership

ENGINEERS FOR AFRICA

Identifying engineering capacity needs in Sub-Saharan Africa

A summary report

Africa-UK Engineering for Development Partnership
October 2012

About the Africa-UK Engineering for Development Partnership

The Africa-UK Engineering for Development Partnership (A-UK) brings together the engineering community in Africa and the UK in a consortium comprising the Africa Engineers Forum, The Royal Academy of Engineering, the Institution of Civil Engineers and Engineers Against Poverty. The aim of the Partnership is to strengthen the capacity of the African engineering profession and promote mutually beneficial links between engineers in Africa and the UK.

Authors

From Engineers Against Poverty
Petter Matthews
Lily Ryan-Collins
Dr Jill Wells

From the Royal Academy of Engineering
Dr Hayaatun Sillem
Holly Wright

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Royal Academy of Engineering
3 Carlton House Terrace
London SW1Y 5DG
Tel: +44 (0)20 7766 0600 Fax: +44 (0)20 7930 1549

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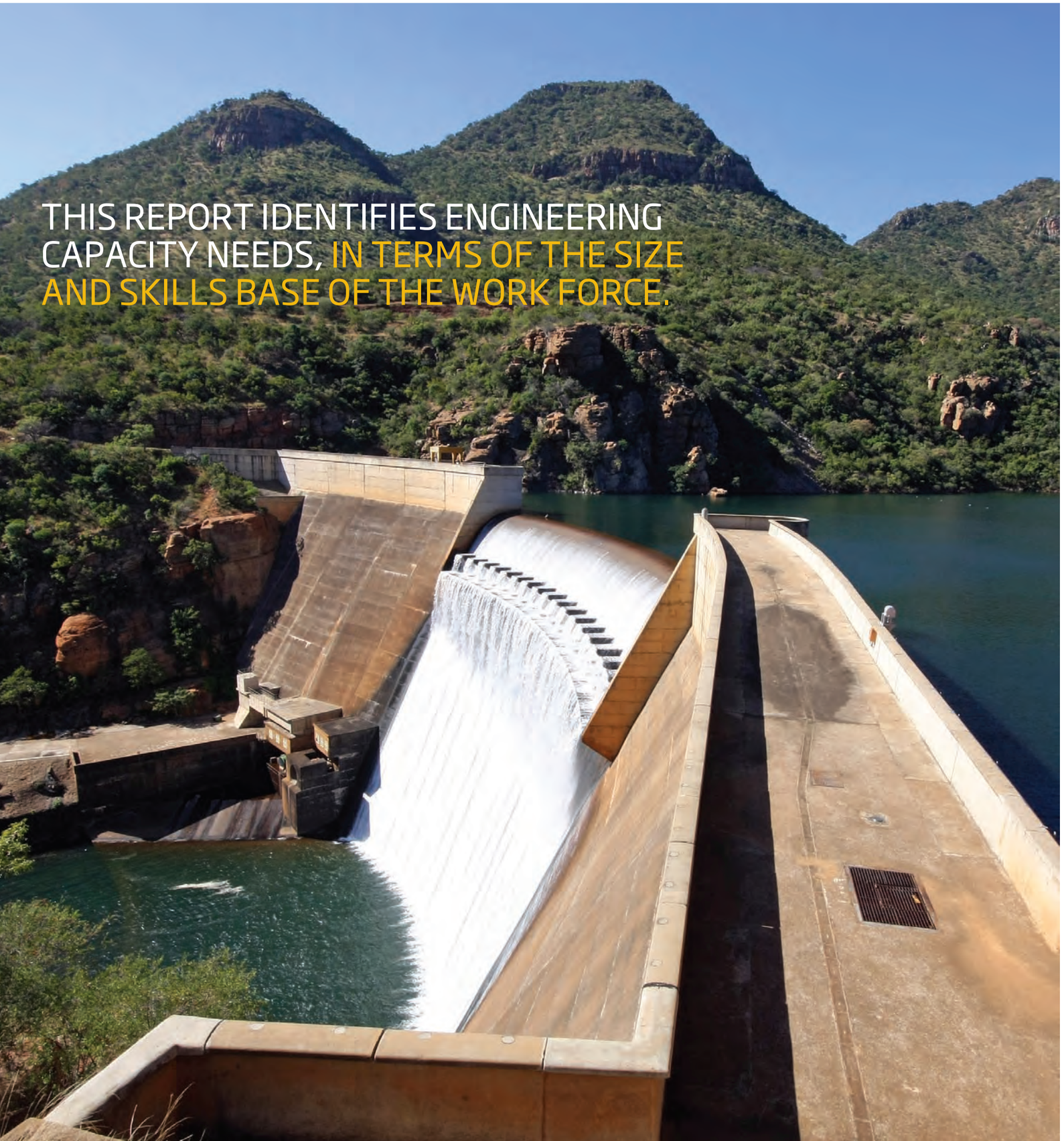

1. Introduction

SUFFICIENT ENGINEERING CAPACITY IS ESSENTIAL TO THE ECONOMIC AND SOCIAL DEVELOPMENT OF ANY COUNTRY. It is a basic requirement for the sustainable provision of infrastructure that enables better healthcare, access to education and the development of an attractive environment for foreign investment. It is also a key driver for innovation and growth. In Sub-Saharan Africa (SSA), infrastructure development lags significantly behind other developing regions. This results in road networks that are fragmented at best, major power shortages in over 30 countries, and very limited access to services for SSA's largely rural population.

The historical view that development can be brought about by imported expertise has given way to an understanding that local innovation and capability must be nurtured so that solutions can be developed in-country. This shift is of particular relevance to those involved in engineering in the developing world, yet in SSA, there is a striking lack of data or literature on the engineering capacity issues that need to be addressed.

This report identifies engineering capacity needs, in terms of the size and skills base of the work force, that are felt across SSA, and sets out potential approaches to meeting these needs that have been put forward by professional engineers and other engineering stakeholders from across the region. The study does not look at other types of capacity (such as engineering research capability), and is by no means a comprehensive study of the situation in SSA which, of course, varies between countries. However, as there is a dire lack of literature on the subject, this report aims to make some progress towards developing an understanding of the issues involved, and paves the way for further in-depth studies in individual countries.

This summary report is accompanied by three supporting documents: a literature review; an analysis of an electronic survey of 113 professional engineers and 29 decision-makers from 18 countries; and an analysis of a set of interviews with 15 engineering stakeholders with experience of leading projects in various countries within SSA. While this study set out to evaluate capacity needs across all engineering disciplines, the majority of interviewees and survey respondents worked in the civil engineering sector and much of the available literature focuses on civil engineering, perhaps reflecting a predominance of civil engineering activity in SSA. It should be noted that the conclusions of this report may be most relevant to the civil engineering discipline.

This summary begins by outlining the scale and nature of capacity needs. It then considers the various causes of low capacity in engineering sectors, followed by an indication of the impact that low capacity has on development. Finally, the paper presents a number of possible approaches to increasing engineering capacity in SSA.

2. The scale and nature of capacity needs

"WE DON'T HAVE ENOUGH MANPOWER IN ENGINEERING. THAT'S THE BASIC PROBLEM".

Sub-Saharan Africa suffers a chronic lack of indigenous capacity in engineering. Quantitatively, there are insufficient numbers of engineers graduating to meet demand in some sub-Saharan African countries. As one interviewee put it, "We don't have enough manpower in engineering. That's the basic problem". Evidence of shortages of engineers was found in all of the countries for which data was available: South Africa, Rwanda, Mozambique, Malawi and Tanzania. Often it is the public sector that bears the brunt of this shortage, as most unfilled posts appear to be in government positions in rural areas. However, there are also notable levels of unemployment among engineering graduates, indicating that the problem is more complex than a simple lack of numbers.

Unemployment among engineering graduates may, in part, be due to a reluctance on their part to take poorly paid positions in rural areas, or due to the dominance of foreign engineering firms who import foreign labour. However, the predominant reason identified in this study was that engineers were graduating without the necessary skills and experience to be employable. One interviewee from Zambia explained that, "The universities are able to churn out the engineers in numbers... but many of them do not have the skills to be able to operate in a global economy". Reflecting the scale of this problem, last year the Kenyan Engineering Board withdrew recognition for engineering degrees from three of Kenya's public universities.[1]

All three parts of this study indicate that low engineering capacity in SSA is more accurately described as an inadequate number of engineers with sufficient skills and experience, than as an insufficient number of engineers per se. The scale of the problem varies between engineering sectors, across the different professional levels, and between countries, but it is a problem that is prevalent right across the region. There is a variety of factors that combine to contribute to this lack of capacity, ranging from global market forces to inadequate education.

...ENGINEERS WERE GRADUATING WITHOUT THE NECESSARY SKILLS AND EXPERIENCE TO BE EMPLOYABLE.

[1] www.universityworldnews.com/article.php?story=20110708163324160

3. Causes of low capacity

42% OF THE PROFESSIONAL ENGINEERS BELIEVED POLICYMAKERS HAD A POOR UNDERSTANDING OF ENGINEERING ISSUES, WITH ONLY 14% BELIEVING THEY HAD A GOOD UNDERSTANDING.

Governments

A number of the root causes of low capacity in SSA relate to government policies or approaches to engineering. A low level of public investment in engineering projects over several decades has meant an inconsistent demand for qualified engineers. This in turn has seriously limited the opportunities for African engineers to gain marketable skills and experience. To some degree, this under-investment may be due to the politicisation of the engineering agenda or a basic failure of policy makers to understand engineering issues. Of the professional engineers who completed the survey for this study, 42% believed policymakers had a poor understanding of engineering issues, with only 14% believing they had a good understanding.

Aside from the issue of underinvestment, governments in SSA often fail to legislate sufficiently to safeguard engineering standards. The reputation of the engineering profession (and therefore its attractiveness as a career) may partly depend on the existence and enforcement of legal requirements for engineers to be professionally registered before being allowed to practice at certain levels. Several of those interviewed for this study claimed that suitable regulations did not exist in their countries, or that existing legislation was not properly enforced.

The failure or lack of regulation in relation to foreign engineering firms is also damaging to local capacity. Local content laws, where they do exist, are often not appropriately enforced to ensure knowledge transfer from foreign companies to local engineers. This is exacerbated by the fact that governments often award contracts for public projects to foreign firms, who can offer lower rates than local providers. This is particularly common in the case of Chinese firms, which are often able to provide cheaper services than local contractors. Again, these factors combine to limit opportunities for African engineers to gain skills and experience.

Education and workplace training

Much of the literature reviewed for this study placed significant blame for the lack of engineering capacity in SSA on poor quality education. This view was widely supported by the interviewees and survey respondents, with 40% of professional engineers who responded to the survey stating that engineering education in their country did not provide graduates with the skills required (although it was clear that education standards varied widely across the region and between institutions). Tertiary engineering education (in universities and technical colleges) in many countries in SSA has not received the investment needed to keep pace with the developed world in recent decades.

40% of professional engineers who responded to the survey stated that engineering education in their country did not provide graduates with the skills required.

[2] Lawless, A. Numbers and Needs: Addressing Imbalances in the Civil Engineering Profession. South African Institution of Civil Engineering (2005).

Engineering courses in SSA are often too theoretical, are based on outdated curricula, and are not relevant to local needs.

Engineering faculties often do not have the resources to provide appropriate laboratory experience. Salaries for academic staff are low, making it difficult to attract high quality staff, and those who do teach at universities are often also engaged in other activities to earn extra income, which absorbs some of their time and distracts them from teaching. In particular, universities struggle to compete with the private sector to attract academic staff with industrial experience.

Crucially, in many countries it is very difficult for engineering students to find work placements in industry, which prevents them from gaining the experience necessary for them to be employable after graduating. Possible reasons for the low number of work placements available are a lack of cooperation by foreign firms, and the small size of many local firms which makes it difficult for them to accommodate students on work placements.

A lack of training for graduate engineers, once in the workplace, is also an important factor contributing to low capacity in the region. The existence of a significant training gap is evident from both the literature review and the interviews conducted here. This finding is supported by the survey respondents, approximately half of whom cited unmet training needs in relation to technical knowledge, with a similar proportion citing unmet training needs in relation to managerial skills.

'Brain drain'

Those engineers who do manage to obtain marketable skills and experience are often inclined to migrate to other countries, where pay and working conditions are better, resulting in a 'brain drain' from SSA. This phenomenon occurs from SSA to other parts of the world, but also within the region. In South Africa in the early 2000s the number of engineers emigrating annually actually matched the numbers graduating[2]. While the number leaving was partially offset by a steady flow of engineers into South Africa from poorer countries on the continent, this in turn undoubtedly had a detrimental effect on the countries those engineers left behind.

As well as moving to other countries, talented engineering graduates are also lost to non-engineering sectors such as banking, finance, IT and management consultancy. Engineering graduates are attracted to these other sectors by better salaries and city locations. In fact, 63% of the professional engineers who completed our survey believed their own salaries to be 'inadequate'. It was also suggested by one interviewee and some survey respondents

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that jobs in finance or government were seen as more prestigious, and so attracted talent away, even from more lucrative engineering sectors.

However, it is striking that 54% of the professional engineers working in SSA who completed our survey rated their job satisfaction as high or very high, and only 8% rated it as low or very low, suggesting that engineering could be a rewarding career for many of the engineering graduates who are attracted to other sectors or other areas of the world.

Engineering institutions

Engineering institutions in SSA are typically poorly resourced, and thus not able to adequately support their national engineering communities. They often don't have the capacity to administer a formal process of registration of engineers, the importance of which is outlined in the 'Governments' section above. They are also often unable to support educational institutions to improve their engineering courses, or to support the professional development of their members, and have limited capacity to provide expert advice to policy makers.

Professional engineers who responded to the survey cited improved continued professional development (CPD) and better access to engineering networks as the two factors with the most potential to improve career satisfaction. This finding highlights the potential contribution that well-resourced and active institutions could have on the quality of engineering careers in SSA.

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4. The impact of low capacity on development

...IMPROVED TRANSPORT, POWER AND COMMUNICATIONS NETWORKS ARE ALL CRUCIAL TO THE DEVELOPMENT OF BETTER HEALTHCARE, IMPROVED MARKET AND EMPLOYMENT OPPORTUNITIES FOR PEOPLE IN RURAL AREAS, AND WIDER ACCESS TO EDUCATION.

A consensus emerged from the literature, interviews and survey that the severe lack of engineering capacity in SSA seriously hinders development in the region.

Most conspicuously, low engineering capacity is an obstacle to the development of national and regional infrastructures, and this has a direct impact on the ability of countries in SSA to achieve development goals. For example, improved transport, power and communications networks are all crucial to the development of better healthcare, improved market and employment opportunities for people in rural areas, and wider access to education.

Where engineering skills shortages are most acute, infrastructure gaps are even more difficult to reduce. The impacts of low capacity are therefore most extreme in rural areas where existing infrastructure is often extremely poor and where it is most difficult to attract skilled engineers to work. Poor infrastructure is also a deterrent to foreign investment. One respondent gave the example of frequent power outages in Nigeria discouraging foreign companies from establishing operations in the country.

Beyond the direct impacts of poor infrastructure, the lack of engineering capacity is also believed to hamper economic growth in several ways. The limited capacity of local providers has led to widespread reliance on foreign engineering contractors. UNESCO[3] has argued that goals for basic service delivery would have a greater chance of being met if local, less expensive engineering expertise was available. Furthermore, reliance on foreign firms can result in capital flight and removes potential employment opportunities from the local market. It can also result in buildings and other structures that don't reflect or suit local needs.

The lack of domestic capacity to develop and manage engineering projects can prevent access to valuable donor funds and support. One interviewee gave the example of an opportunity for Zambia to secure £300 million of World Bank funding that was lost due to these sorts of capacity issues within government ministries. Furthermore, as Professor Calestous Juma HonFREng notes, lack of engineering capacity imposes limitations on SSA's ability to use its abundant natural resources to, "harness the power of science and innovation to meet development objectives and be competitive in international markets".[4]

[3] UNESCO Engineering: Issues, Challenges and Opportunities for Development. UNESCO Publishing, 2010.

[4] Juma, C, Hinton Lecture, 'Redesigning African Economies', 2006.

5. Capacity building strategies

"Without these links the training institutions are not able to address the inadequacies in their training, and industry is not able to utilise the products from the universities".

The challenges involved in building engineering capacity in SSA are daunting, but this study highlights a number of complementary strategies and approaches to address the key causes of low capacity.

Research and data

There is a striking dearth of data and literature on the subject of engineering capacity in SSA. In the process of identifying existing research for the literature review section of this report, it became clear that not only was there very little literature focussed on the subject, but that more general studies on related topics, such as water and energy, often failed to mention the highly relevant issue of engineering capacity.

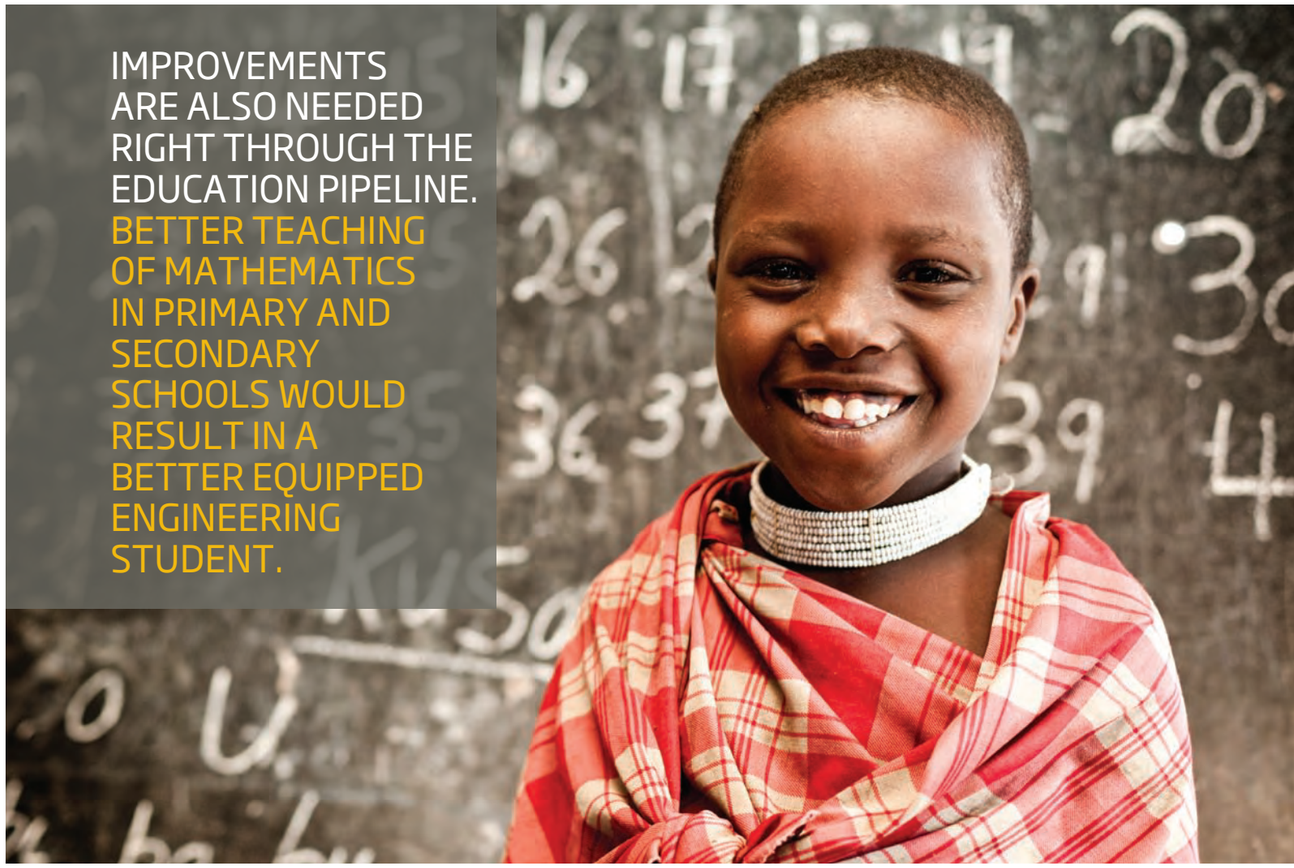
In order to develop strategies for building engineering capacity that are targeted and effective, it is vital that more detailed research is undertaken into the various engineering sectors in each country in SSA. As well as providing the necessary evidence to develop suitable programmes to build capacity, this would also raise awareness among stakeholders (governments, donors etc) about the nature and extent of the problem.

Education and training

The need to improve tertiary engineering education is paramount if engineering capacity is to be developed in SSA. There is a clear need for the development of curricula to bring them up to date with current industrial practice, to tailor them to local needs and to bring engineering education in line with international norms such as the Washington Accord[5]. A greater emphasis on practical experience and skills such as project management would also improve the standard of graduates.

Public investment in engineering education is essential if these kinds of improvements are to be made. In all three parts of this study, there was also strong support for the view that tertiary education should be improved through the development of partnerships between academia and industry. One interviewee reflected a view held by most others when he explained that, "without these links the training institutions are not able to address the inadequacies in their training, and industry is not able to utilise the products from the universities".

There are several examples across the developing world of successful partnerships in which engineering firms invest in engineering departments that are local to the areas in which they operate. One mining company with operations in Tanzania (whose CEO was interviewed for this study), for example, provides work placements, scholarships and bursaries for students at Dar es Salaam University. Such activities allow companies to develop a local workforce for their activities in the long term. Partnerships between academia and industry could also provide a vehicle to increase the number of work placements available to engineering students, to allow them to gain the practical skills that they will need in order to be employable.



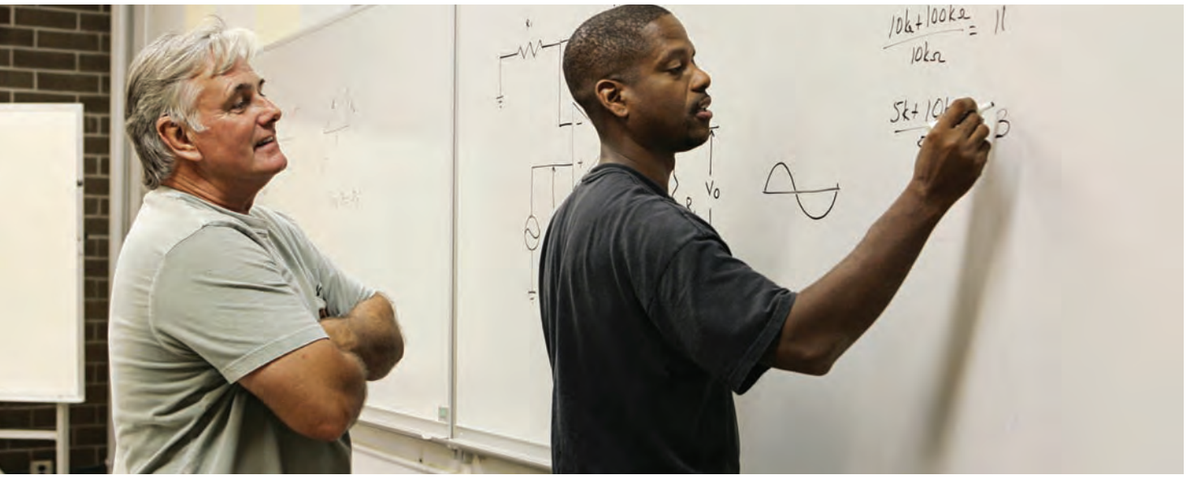
Improvements are also needed right through the education pipeline. Better teaching of mathematics in primary and secondary schools would result in a better equipped engineering student. More pressing is the need for more and improved CPD for engineers following graduation, if the capacity of the engineering workforce is to improve. Among survey respondents, improved CPD was the most commonly cited change that would most improve their career satisfaction. To ensure that private engineering firms take responsibility for providing training for their employees, and to oversee standards of CPD, governments and professional bodies each need to play a part, as discussed in the relevant sections below.

Professional institutions

Professional engineering bodies have an overarching role to play in supporting the development of engineering capacity in SSA countries. They should work to develop and enforce professional qualifications requiring appropriate experience for all senior engineering positions. They should also strive to improve relations with government in order to contribute towards the development of evidence-based policy formulation and coherent public investment. By recognising tertiary education courses and setting course standards, professional bodies could support education institutions in improving curricula and teaching methods. Finally, professional bodies could do more to support and promote CPD.

While adapting current practice can result in significant progress in these areas, most professional engineering bodies in SSA

[5] www.washingtonaccord.org/



are also constrained by a severe lack of resources. In order to be most effective, professional institutions need to build internal capacity by adapting their business models and by seeking ways to fund their activities. Governments need to play a role in helping these bodies to increase their capability, by providing funding directly for professional bodies that can provide coherent strategies, and by legislating on compulsory registration of engineers to their relevant professional body, which would provide a stable source of income to institutions.

Donors also have a role in helping to build capacity within professional institutions. Lessons can be learned from existing institution capacity building efforts in other fields, such as the Royal Society Pfizer African Academies Programme for national science academies.[6]

Government approaches

There are two key areas in which government legislation could contribute to engineering capacity building in many countries in SSA. Firstly, making it compulsory for professional engineers to be registered with their relevant professional body would ensure certain standards of practice, which in turn would gradually improve the quality and reputation of the indigenous engineering workforce.

Secondly, the development of appropriate 'local content' laws should be used to ensure that there is a process of knowledge transfer from foreign engineering companies to local engineers. In both cases, it is important that such legislative measures are fully enforced.

More generally, policymakers in SSA need to develop a better understanding of the engineering sector; the majority of professional engineers who responded to the survey for this study believed that policymakers in their countries had a poor understanding of engineering issues. In particular, governments must recognise the impact that low engineering capacity has on the ability of their countries to develop. Initially, collecting and analysing data on national engineering needs is crucial.

Led by research of this kind, governments must work with engineering stakeholders to develop policies and make long-term investments that support and foster professional bodies, education institutions, and local private engineering firms. It is important for policymakers to recognise that engineers can help to support better decision making in key areas such as infrastructure, transport, energy, water and sustainability.

[6] www.royalsociety.org/about-us/international/pfizer-african-academies/

Regional and international cooperation

International cooperation and knowledge sharing has the potential to be an important capacity building avenue for countries in SSA. Donor support from international organisations remains important in much of the region, and it is essential that donors make greater efforts to make engineering capacity building a key focus of their activities, rather than 'bolting' it on infrastructure projects as a secondary activity.

Partnerships between engineering education institutions in SSA and in developed countries, such as the MIT ilabs project[7] and the higher education partnership project initiated by the Association of African Universities and the Association of Universities and Colleges of Canada[8], facilitate knowledge sharing, and more partnerships of this kind would be beneficial. Furthermore, South-South partnerships and relationships with engineering stakeholders in other countries within SSA are increasingly considered crucial, as technologies and approaches developed in these regions might be more relevant than those established in regions such as North America and Europe.

The diaspora of engineering professionals from countries in SSA could also play a greater role by sharing the knowledge, skills and access to networks that they have gained abroad with their home countries. They could also help to raise awareness internationally about the issue of engineering capacity needs in SSA. Diaspora networks such as the Africa Diaspora Network could help to promote and facilitate such efforts.

...POLICYMAKERS IN SSA NEED TO DEVELOP A BETTER UNDERSTANDING OF THE ENGINEERING SECTOR...

[7] http://icampus.mit.edu/ilabs/

[8] www.aau.org/?q=content/the-official-launch-aau-aucc-partnership-project

6. Conclusions

There is a severe lack of engineering capacity in SSA. Whilst there is variation between countries, it is evident that across the region the engineering sector suffers from a shortage of skilled and experienced engineers. This lack of capacity at every level of the profession is a substantive obstacle to achieving almost all development goals, from the provision of basic sanitation to the reduction of rural poverty.

The key causes of low capacity include: a lack of government investment in engineering skills development right along the pipeline; out-of-date curricula and teaching methods at universities, resulting in graduates lacking required skills; weakness of professional institutions, leaving professional engineers unsupported and resulting in insufficient or non-existent registration processes; lack of knowledge transfer from foreign engineering firms; failure by the private sector to provide sufficient CPD; and 'brain drain' of engineering talent to other sectors and other countries.

Overcoming these causes of low capacity will be a formidable task. However, there are a number of practical ways forward that will enable the engineering workforce in SSA countries to gain the skills and experience needed to facilitate development. Progress can be made in the fields of education, policymaking, strengthening of professional bodies, and in better engaging the private sector. The recommendations made in this paper should inform governments, donors, professional and educational bodies, and engineers themselves on a range of measures that can be employed to build engineering capacity in SSA.

PROGRESS CAN BE MADE IN THE FIELDS OF EDUCATION, POLICYMAKING, STRENGTHENING OF PROFESSIONAL BODIES...

Key conclusions and recommendations

The conclusions and recommendations below are not just demands for greater investment. Instead, they address the need for a better understanding of the crucial role that engineering capacity plays in enabling development in SSA, with a view to improving investment decisions and supporting more effective deployment of resources.

A lack of domestic engineering capacity is a serious impediment to economic growth and the achievement of national development goals. Governments, donors, and industry stakeholders must acknowledge this and work with the engineering profession to better characterise the problem and develop policies and practical approaches aimed at addressing it.

There is a widespread need for greater recognition that the benefits of investing in physical infrastructure extend beyond the built assets and the services delivered, and include the socio-economic benefits associated with building and maintaining those assets.

Countries that rely on foreign investment and expertise in the engineering sector must develop strategies that use that investment, and the presence of foreign professionals, to build domestic capacity and reduce that reliance in the long term.

International agencies need to:

Invest in research to map engineering capacity needs and to better understand the causes of low engineering capacity.

Undertake joint programme reviews with government partners to establish what engineering capacity building support is currently being provided and identify opportunities to do more.

Ensure that all investments in science, engineering, technology and infrastructure include an integrated capacity building component.

Use procurement systems to optimise the proportion of goods and services sourced from domestic suppliers when investing in infrastructure and associated services.

Governments need to:

Invest in research to map national engineering capacity needs.

Use intelligent industrial policy – such as local content requirements, infrastructure investment and 'buy domestic' government procurement – to create jobs, promote enterprise development and improve skills training.

Create mechanisms, such as industrial advisory boards, that put engineering knowledge at the heart of public policymaking.

Establish and enforce a statutory requirement for the professional registration of engineers and support the engineering institutions in maintaining professional standards.

Invest in improving engineering education through provision of resources, teacher training, and support for programmes to improve curricula.

Develop policies aimed at providing incentives to prevent 'brain drain' from national engineering sectors.

Industry needs to:

Build stronger links with higher education institutions to help ensure that new graduates are equipped with the skills, knowledge and attitudes that industry requires. This could be achieved through providing industrial placements for academic staff, work placements for undergraduates and contributing to curriculum review processes.

Provide more frequent CPD opportunities for engineering staff.

Foreign companies with operations in SSA need to increase efforts to ensure knowledge transfer to local engineers.

Professional institutions need to:

Put pressure on Government to establish and enforce a requirement for the professional registration of engineers as a means to enhance levels of professionalism, as well as ensuring a reliable source of income and improving the support offered to members.

Establish and enforce a requirement for members to maintain and enhance their competence through CPD.

Higher education institutions need to:

Establish a process to routinely review and update engineering curricula to ensure they meet the needs of industry and develop the skills required for the achievement of national development goals.

The curriculum review process should involve all staff to ensure ownership of the improvements and should reflect student experiences of being taught.

Build stronger links with industry by, for example, involving industry partners in curricula reviews, creating opportunities for sponsorship, helping to find industry work placements for students, and offering visiting fellowships.

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Royal Academy of Engineering
3 Carlton House Terrace
London SW1Y 5DG
Tel: +44 (0)20 7766 0600
www.raeng.org.uk

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