Towards Capacity Building and Sustainability in Engineering Education in Southern Africa.

Wilson R. Nyemba[1], Zvikomborero Hoko[2], Tauyanashe Chikuku[3], Elisha Mabunda[4]

[1]University of Zimbabwe, Department of Mechanical Engineering,
nyemba@eng.uz.ac.zw
[2]University of Zimbabwe Department of Civil Engineering,
hoko@eng.uz.ac.zw
[3] University of Zimbabwe, Department of Mechanical Engineering,
tauyanashec@yahoo.co.uk
[4] University of Zimbabwe, Department of Electrical Engineering,
emabunda50@gmail.com

Abstract

An acute shortage of appropriately-skilled engineers constrains economic growth and hinders sustainable development. This challenge is shared by most countries in Southern Africa, albeit at different scales. Recession in the region at the turn of the new millennium led to an exodus of experienced professionals, including engineers, seeking work abroad. As a result, most Higher Education Institutions (HEIs) have had to appoint fresh graduate engineers with little or no practical experience to offer training to future engineers. Realising this, the Royal Academy of Engineering (RAE) has partnered with the Faculty of Engineering at the University of Zimbabwe (UZ) to implement a project to enrich engineering education in Southern Africa in collaboration with other regional institutions and partners from industry. The broad objective of the project is to empower the young and inexperienced academics as well as reskill the senior ones through industrial attachments, professional training, knowledge sharing workshops and collaborations with other institutions. The project has recorded significant progress in all areas that were planned for implementation and plans are underway to establish a robust and sustainable network of Southern African Engineering Education Institutions, which by sharing and disseminating knowledge and best practices in engineering education will stimulate a synergistic raising of standards in engineering education across the region. This paper outlines progress that has been made since the inception of the project in August 2013 and strategises on ways in which engineering capacity can be built and sustained at these institutions by scaling up the project beyond the current phase.

Keywords: *Hub Institution, Spoke Institution, Higher Education Institutions, Secondment, Knowledge Sharing, Capacity Building, Professional Training, Collaboration, Sustainability*

1. Introduction

Enriching Engineering Education in Southern Africa is a project hosted by the University of Zimbabwe (UZ)'s Faculty of Engineering as the hub institution, in partnership with six spoke institutions from the region as well as other stakeholders from the government of Zimbabwe, parastatals and industry. This came out of the realisation that Southern Africa suffers from a serious and persistent lack of engineering capacity according to studies conducted in Malawi, Mozambique, Rwanda, South Africa, Tanzania and Zimbabwe (Matthews, *et al*., 2012a, &

2012b). This is attributed not only to low numbers of qualified engineers but insufficient skills and experience held by some of the few local engineers. This is compounded by the fact that the majority of institutions that offer engineering training in Southern Africa have outdated equipment and machinery for training of students. As a result, the curricula and its development thereof, has not moved in tandem with rapid trends in technology experienced by the developed world, leading to universities producing graduates who are not very relevant to the needs of industry (Nyemba, *et al*., 2014). The absence of links between educational institutions and industry, creates qualified but unemployable professionals. Several stakeholders from the private sector have pointed to the coordination problems among employers, professional associations and educational institutions in training programs for engineers (World Bank, 2010).

In collaboration with the RAE and the African Engineers Forum, the Institution of Civil Engineers (ICE) is a lead partner in the Africa-UK Engineering for Development Partnership which aims to strengthen the networks of engineers across Africa, build the capacity of the African engineering profession and promote mutually beneficial links between engineers in the UK and Africa (Goodsir, *et al*., 2009). It was through this initial association that the UZ went into collaboration with the RAE, partly facilitated by the Zimbabwe Institution of Engineers (ZIE) and a proposal was presented to address some of the key issues. This led to a two year project fully funded by the RAE. The main objective of this project is to improve the practical skills of academics through secondment to industry, interactive knowledge sharing with partner universities and industry, and professional training.

In its 2011 to 2015 Strategic Plan, the UZ intends to increase its efforts aimed at producing more Masters and Doctorate graduates so that by the end of 2015, at least 50% of the UZ student population will be post-graduate students (UZ, 2011). The UZ recognises that highly skilled citizens and professionals provide expertise for the labour market and should be able to address specific national and global issues. For the University to continue being relevant to the nation, its work must produce developments that are of some immediate use to society, not just ‘advancement of knowledge’. This paper looks at the progress and achievements to date and provides strategies for future developments with a focus on capacity building and sustainability beyond the current phase of the project.

2. Project Management and Implementation

2.1 Project organisation

The project is managed through a two-tier structure (Figure 1); the Implementation Committee, made up of staff from the hub institution, responsible for implementation and the Steering Committee, made up of representatives from each of the participating institutions and stakeholders, responsible for the overall management of the project. Both committees are chaired by the Project Manager. The funds are received, handled and managed by the UZ Projects Office.

2.2 Project Partners

Stakeholders for the project comprise the seven HEIs, ZIE, Research Institutions in Zimbabwe, the Government of Zimbabwe and related parastatals as well as industry and the private sector as shown in the hub and spoke institutions relationship in Figure 2.

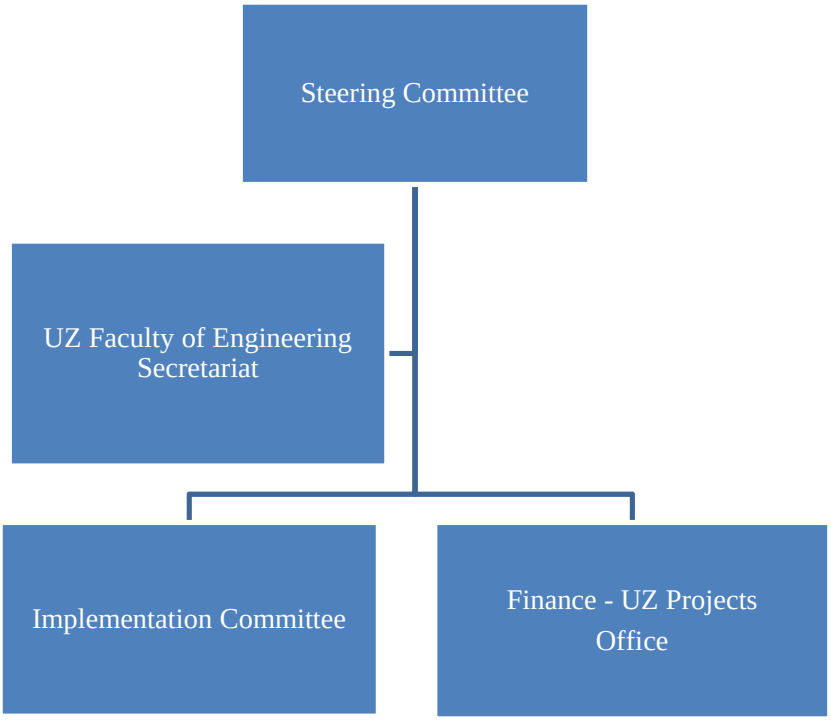

Figure 1. Project Management Structure

Figure 2. Project Partners

Participation from the Government of Zimbabwe has mainly been through parastatals such as the Zimbabwe Electricity Supply Authority (ZESA) and its subsidiaries, Zimbabwe National Water Authority (ZINWA), City of Harare, Research Council of Zimbabwe and the Scientific Industrial Research and Development Centre (SIRDC) while the private sector has been actively represented by companies such as Zimbabwe Platinum Mines (Zimplats), Craster International, Asea Brown Boveri (ABB) and Econet Wireless.

2.3 Project Activities and Progress

In line with the original objectives, progress has been made in virtually all three areas of; secondment, through attachment of UZ staff to various companies, knowledge sharing through the various workshops and seminars that have been held so far and professional training through developing and equipping both technical and academic staff with skills to operate modern equipment such as Computer Numerically Controlled (CNC) machines.

2.3.1 Staff Secondment to Industry

The starting point in addressing some of the challenges highlighted in the Introduction would be to empower the university staff through exposure and use of modern machines and technology in industry. In this regard several technicians and lecturers from the UZ were attached at various companies in and around Harare while one was attached at a consulting company in South Africa, as summarised in Table 1. The low numbers of female academics at partner institutions is common but the few available benefited from the project such as shown in Figure 3.

Table 1: Companies & Staff Secondment Schedule

COMPANY	DATES	DURATION	NUMBER OF ACADEMICS	NUMBER OF TECHNICIANS	TOTAL
Asea Brown Boveri, Bulawayo	1 Jul to 31 Aug 2013	62 days	0	1	1
ZIMPLATS, Selous	8 Jul to 30 Aug 2013	54 days	2	2	4
City of Harare, Surveying Department	21 Jul to 22 Aug 2014	30 days	0	1	1
Craster International, Foundry and Machine-shop in Harare	7 Jul to 22 Aug 2014	46 days	1	0	1
Zimbabwe National Water Authority, Harare	21 Jul to 22 Aug 2014	30 days	0	3	3
Jeffares and Green Consulting Engineers, Pietermaritzburg, RSA	21 Jul to 22 Aug 2014	30 days	1	0	1
ZIMPLATS, Selous	7 Jul to 22 Aug 2014	46 days	2	1	3

TOTAL		**298 days**	**6**	**8**	**14**

Figure 3. A Young Female Academic who was attached at Craster International Foundry.

One notable achievement from the project was the involvement of both technical and academic staff on the UZ Groundwater project. The Faculty of Engineering's personnel, most of whom had been attached at various companies as summarised in Table 1, were involved in the design and development of the groundwater system at the UZ. Because of failure by the local authorities to provide adequate and fresh water to Harare, the Faculty took up the challenge to develop a successful groundwater supply to the entire campus. The design team consisted of technicians and academics (professional engineers) from Land Surveying for the provision of routes for the pipe network and levelling, Civil Engineering for all the civil works and construction of sump and pump house, Mechanical Engineering for the fabrication of pump house pipes and sizing and selection of both submersible (borehole) and booster pumps and Electrical Engineering for powering and controlling the network. The system developed also included a purification plant for chlorinating and thus supplying clean water to the community (Figure 4).

Figure 4. Technical Staff at Work Installing the Chlorinators in the Pump House

2.3.2 Professional Training

Most of the equipment in the Faculty of Engineering at UZ is now old and obsolete. A proposal to re-equip the workshops and laboratories with modern equipment was presented and accepted by the University authorities and therefore the Faculty has gradually been purchasing these. However, one major challenge that the Faculty would have faced was the lack of skills to operate these new machines. Part of the project funds were thus utilised to train 10 academics and technicians in the use and programming of CNC machines. Thus the machines that have been purchased so far are not idle but are now readily used for projects and practicals. Figure 5 shows one of the beneficiaries of Professional Training, programming a CNC machine.

Figure 5. CNC Programming under Professional Training.

2.3.3 Knowledge Sharing Workshops and Seminars

'A problem shared is a problem halved' is the philosophy upon which the third objective of the project is based. The problems highlighted in the Introduction are not unique to the UZ. In addition to the problems of inadequacies in equipment and high vacancy rates, recession in the region from 2000 led to a brain drain with experienced professionals seeking work abroad. As a result, most HEIs have had to appoint fresh graduate engineers with little or no practical experience to offer training to future engineers. This objective not only dwells on sharing knowledge and experiences from the regional institutions but also goes further to look at available resources, both human and equipment, with the ultimate objective of sharing the same. Several workshops and seminars involving the seven regional HEIs as well as industry and Government of Zimbabwe institutions have been held as summarised in Table 2. A number of resolutions have been made, some of which have been implemented and some are in the process as detailed in the latter sections of this paper.

The workshops mainly covered experiences from the institutions while industry highlighted their problems and how they wish academics can contribute. The seminars have mainly been devoted to feedback from the technicians and academics who would have been attached at the various companies in industry. The Faculty of Engineering also hosted a highly experienced mining engineer who spent some time going through all the Departments and their curricula. Very useful suggestions were drawn from the end-of-visit seminar in which a number of resolutions were also captured, with the intention of improving the Faculty curricula.

Table 2: Workshops and Seminars Held To Date

DATE	DETAILS	VENUE	NUMBER OF PARTICIPANTS	DRAWN FROM
25-28 September 2013	Workshop 1 (ZIE Congress)	Great Zimbabwe, Masvingo	Over 200 delegates (13 funded by the project)	UZ – 12 and CUT – 1
19-21 November 2013	Workshop 2	Chinhoyi University of Technology	50	All 4 local Partner HEIs, Industry, Government and Parastatals. Included Feedback Seminar 1
25 March 2014	Workshop 3	UZ, Faculty of Engineering	62	All 7 partner institutions, Government of Zimbabwe, industry and parastatals
10 October 2014	Feedback Seminar 2	UZ, Faculty of Engineering	63	Mostly UZ Staff and invited industry stakeholders where staff were attached.
6-7 November 2014	Workshop 4	Wild Geese Lodge, Harare	95	All 7 partner institutions, Government of Zimbabwe, industry and parastatals
13 November 2014	Visiting Fellow Seminar	UZ, Faculty of Engineering	63	Mostly UZ Staff and invited industry stakeholders where staff were attached.

3. Project Outcomes and Impact

The Faculty of Engineering at the UZ through four of its Departments designed and developed a highly successful groundwater supply system. Most of the staff, technicians and professional

engineers who worked on this project were drawn from staff who had been seconded to industry and used skills gained during their attachments. This is one success story that has helped motivate staff and are now more willing to partner others in team projects. As a result of the highly successful groundwater project, the UZ authorities have been quite receptive to the needs of the Faculty and thus set priority in providing funding for modern equipment which include CNC Machines for the various workshops. Ten technicians and lecturers were funded by the project to attend a professional development training course in CNC Programming and Machining and are now able and competent to use the machines for projects as well as lectures.

As an outcome of Workshop 2, the Faculty of Engineering, with the assistance and participation of industry and partner HEIs were able to craft the first ever Research Agenda for the Faculty. The Workshop discussions yielded useful research area questions from the engineering sector in Zimbabwe. Based on an inventory of these felt needs, the Zimbabwe National Research Priority Areas, inputs from the Zimbabwe Agenda for Sustainable Socio Economic Transformation (ZimASSET), the research objectives of the UZ, the Research Council of Zimbabwe and other collaborating HEIs, four thematic research groups were also formed and collaborations among the institutions and industry are in progress. Within the research groups, the Workshop also produced a number of main research areas or themes in support of the overall focus of the Faculty of Engineering. Future PhD/DPhil and MSc/MPhil studies under the Faculty, as well as the research to be carried out by staff is expected to fit within these thematic areas in order to build up the necessary academic capacity and research momentum (Faculty of Engineering, UZ, 2014).

Through interactions with students and feedback from student/course evaluations, an appreciation of these positive developments has been expressed. It is also quite evident from the interest and participation of both technicians and lecturers at the various workshops that those seconded to industry have been motivated and are now more confident in the delivery of their duties. Academics have also reported an improvement in their research output, in terms of publications as evidenced by the number of papers produced by the Faculty staff in 2014 (UZ, (2014).

The increased interest from industry and the collaboration with other regional HEIs have stimulated debate for growing the project further and beyond the current phase as articulated in the future projections section of this paper. Participation of industry and government institutions such as parastatals and research institutions has also created opportunities for broadening the research portfolios for the collaborating HEIs and thus narrowing the gap between industry and academia. The practice of seconding academics to other institutions and the provision of industry positions for the same during sabbatical leave has been in place in other parts of the world including the UK. In Africa, such practice in Nigeria and Ghana has proved beneficial for both academia and industry (Afonja, *et al*., 2005*).*

4. Monitoring and Evaluation

To ensure that the project remains on course and focused on the original objectives, some monitoring and evaluation mechanism has been put in place. The monitoring and evaluation of this project is two pronged: i.e. self-assessment and external assessment. For the self-

assessment, recorded testimonials from individuals who participated in attachments to various companies have been captured.

Report-back and feedback seminars by academics and technicians who have been seconded to industry as well as those who have been funded for professional training and development have been useful in that the management team has revised and restructured some of these in order to improve the outcomes. The feedback provided by industry such as the need to have the attachments for a longer period have already been addressed in that the attachments are now earmarked for at least 2 months or longer in the case of those who opt to take their sabbatical leave for that purpose.

As is required by the project funders, periodical narrative and financial reports are produced and submitted for approval by the RAE. So far these have all been accepted and are the basis for further fund disbursements. The Implementation Committee meets on a regular basis, not only to review progress but also to plan the day to day activities of the project. In addition, the overall governing body, the Steering Committee also meets periodically to consider and review activities of the project as well as recommend periodical narrative and financial reports to the RAE.

Visits by industry fellows have also assisted in ensuring that the university programs are refined and kept in line with industry trends ad modern methods of engineering design and development. This also assists in ensuring that universities are training and producing relevant graduates. To date, all activities and proceedings of the workshops in the project have been documented and published, including the first ever Faculty of Engineering 2014 – 2018 Research Agenda. Towards the end of the current phase, an independent external assessment will be carried out to ensure that all project activities carried out to date are in line with the agreement and the implementation plan. Where possible, suggested improvements will also be incorporated.

5. Future Projections

Based on the success of the project so far, there has been growing interest, evidenced by the increased number of participants from both industry and academia as well as the levels of participation. This has stimulated the need to not only strengthen the project but to expand the scope and scaling up the project beyond the current phase. Through the Implementation and Steering Committee meetings as well as the workshops and feedback seminars, a number of resolutions have been put forward to guide and direct the project beyond the current phase.

First and probably most importantly, all stakeholders have unanimously agreed that this has been a worthwhile project and that there is need for all players to organise themselves into a legally constituted grouping that can be used to apply for financial support for furthering objectives of the project. The management team are now working on the formulation and establishment of a network of engineering institutions in partnership with industry from the region for furthering the overall objective of bringing industry closer to academia and vice versa. Thus, the establishment of the Southern Africa Engineering Education Network (SAE^2Net) is in the pipeline and should be constituted and be in place by the first quarter of 2015. This will initially involve the current participating HEIs and industry but more players can be co-opted in due course as the network grows and hopefully succeeds.

Having largely achieved success in the three main objectives of this project, i.e. industrial exposure, knowledge sharing and professional development training, the question that quickly comes to mind is whether this will be sustainable beyond the life-span of the current phase. It is thus important, whether funds are available or not, to ensure that the momentum that this project has gathered so far should be maintained. Through the various workshops, seminars and attachments where stakeholders from industry and regional HEIs have interacted, participants outlined their strengths and weaknesses. The idea of a regional network can then be used to pool complementary strengths at each of the institutions and share the human and equipment resources as far as possible. This can be achieved through the establishment of a Master's degree in Engineering where students will initially be registered for common courses and then allowed to specialise in a field of their choice of which the specialisations will be based at the various institutions depending on their strengths in a particular area. Plans are underway to identify these strengths in parallel with the proposed establishment of the network which will govern the operations as well as the modalities on how the regional MSc in Engineering will be managed. The absence of institutions that offer specialised post-graduate courses due to the limitations and lack of capacity and quality of professional education institutions have been noted in several East African countries, as has the absence of institutions that offer academic and professional training courses for middle-level professionals (World Bank, 2010). In line with this, it is also the long term plan that participating institutions can also collaborate and offer joint research leading to PhDs in Engineering. The two arrangements will thus certainly benefit those institutions that are short of expertise in all or some of their disciplines.

Funds permitting, it will also be ideal to hold annual regional conferences involving participating institutions and industry where knowledge and experiences in research and development in engineering can be shared. This will also be a way of publicising outputs from the collaborative regional PhD and MSc researches. Among the challenges observed prior to embarking on this project were not only the lack of skills by the inexperienced young engineers but also the low levels of qualifications, the majority of lecturers being MSc holders. Training to higher levels will certainly ensure that capacity to sustain such network activities will be realised. Collaborations of this nature can help a great deal in shaping the curricula at participating institutions in line with current trends and what industry needs. Stakeholders at the last workshop also agreed to use such fora to review curricula and this will be one of the major activities in 2015.

There has been tremendous interest from partners in the United Kingdom following the Project Manager's participation at the recent Visiting Professors and Visiting Teaching Fellows Conference held in Birmingham, England and facilitated by the RAE. The regional project could tap into this and involve these Professors so that a reputable annual journal can also be produced to publicise research and engineering activities in the region.

According to the Government of Zimbabwe, Statutory Instrument 153 of 2012 read together with the Engineering Council of Zimbabwe Act, CAP 27:22, all practising engineers and technicians in the country are required to register and renew their practicing certificates (Government of Zimbabwe, 2012). This can be done by accumulating 15 CPD points annually and this can achieved through various proven professional activities such as teaching, attending workshops,

presenting or publishing papers etc. This requirement is not unique to Zimbabwe although the requirements may vary from country to country. Stakeholders at the various workshops and meetings also agreed to include Professional Development Training as one of the key network activities in order to assist and facilitate the development and thus registration of participating engineers and technicians in the project.

It is quite evident from this paper that most activities have been centered on staff from the UZ while participation from the other HEIs has been limited to workshops. Stakeholders have also recommended more active participation and involvement of spoke institutions in all key objectives and this has been earmarked as one of the major changes to the proposed Phase 2 of the project. It has also been proposed and unanimously agreed that in line with the requests from industry to prolong the period of attachment, academics have been encouraged to make use of their sabbatical leave, usually a minimum of eight months, to be attached and gain experience and skills from the various companies that have shown interest to host university staff. Other staff who may not be entitled to sabbatical leave can even make use of their ordinary leave as the attachment ultimately benefits them more.

The involvement of industry has been commendable although more players are expected to participate. A number of options have been proposed to stimulate interest and participation from industry, for example, the use of Build, Operate and Transfer (BOT), where, for instance, industry can fund to establish a laboratory to carry out tests for their companies while utilising space and expertise from the universities until such a time that they can offer to donate the equipment to the universities. Another way is where industry accommodates university staff for attachment in exchange for the provision of solutions to some of their operational challenges.

6. Conclusions

Enriching Engineering Education in Southern Africa is a project funded by the RAE involving seven regional HEIs, Government of Zimbabwe, its parastatals and industry, with a broad objective of bringing industry and academia closer through secondments, research collaborations, professional training and knowledge sharing while empowering academics through acquisition of the much-needed skills and expertise. The project has stimulated a lot of interest, evidenced by the growing number of participants particularly from the private sector and government parastatals. It is within this context that stakeholders have unanimously recommended the extension and scaling up of the project beyond the current phase which comes to an end in July 2015.

UZ staff who have been seconded to various sectors in industry have derived a lot of benefit that has helped in not only motivating them to be confident in delivery of lectures and conducting laboratories and workshops but has also helped in creating a platform for collaborative research and publications. Some of these academics and technicians were key in the design and development of the successful UZ groundwater project, a typical example of applied research and community engagement by the Faculty of Engineering staff. Some of the technicians and academics have also been empowered by way of professional training to enable them to program and operate CNC machines that the Faculty recently acquired.

So far four workshops and three feedback seminars have been held and this has been an opportunity for staff from the participating institutions and industry to share knowledge and experiences, a perfect opportunity to also network and lay foundations for collaborations. A number of resolutions have been recommended at some of these gatherings, chief among them being the unanimous recommendation to establish a regional network of engineering institutions through which funding can be sought as well as share the minimum resources available at these institutions. This will be the priority for the second phase of this project in which more players from the Southern African Federation of Engineering Organisations (SAFEO) are expected to join and participate. It is also within this context that a regional Master's degree in Engineering has been proposed with specialisations at the participating HEIs depending on their strengths. It is also expected that the pool of expertise from the HEIs can collaborate to supervise higher degree qualifications such as PhDs.

7. Acknowledgements

The project management team would like to acknowledge the financial support received thus far from the RAE and management support from that organisation's International Policy Advisor, Ms. Meredith Ettridge as well as Mr. Petter Mathews from Engineers Against Poverty. The Implementation Committee from the UZ and the Steering Committee of representatives from participating institutions have ensured that the project flows smoothly and their inputs are also acknowledged.

8. References

Afonja, A. A., Sraku-Lartey, K. and Oni, S. A., (2005*), Engineering Education for Industrial Development. Case Studies of Nigeria, Ghana and Zimbabwe*, African Technology Policy Study Network, ISBN 9966-916-64-4

Faculty of Engineering, University of Zimbabwe, (2014), *2014 – 2018 Research Agenda*, Mac Designs.

Goodsir, S., Murray, M. and Jowitt, P., (2009), *Engineering Capability in Rwanda, Final Project Report*, United Kingdom National Commission for UNESCO Scotland Committee.

Government of Zimbabwe, (2012), *Statutory Instrument 153 of 2012, Engineering Council (General) By-Laws,* Zimbabwe

Matthews, P., Ryan-Collins, L., Wells, J., Sillem, H. and Wright, H., (2012a), *Engineers for Africa: Identifying Engineering Capacity Needs in Sub-Saharan Africa, Literature Review*, Royal Academy of Engineering.

Matthews, P., Ryan-Collins, L., Wells, J., Sillem, H. and Wright, H., (2012b), *Engineers for Africa: Identifying Engineering Capacity Needs in Sub-Saharan Africa, Analysis of Stakeholder Interviews*, Royal Academy of Engineering.

Nyemba, W. R., Hoko, Z., Brooking, G. and Chikuku, T. (2014), *Innovative Strategies to Enrich Engineering Education in Southern Africa*, 7th Congress Proceedings of the Zimbabwe Institution of Engineers, Great Zimbabwe, Masvingo, 25-27 Sep 2013, Vol. 1, Number 1, Pages 213-221, ISBN 9780797460072

University of Zimbabwe, (2011), *2011 – 2015 Strategic Plan*, University of Zimbabwe

University of Zimbabwe, (2014), *University of Zimbabwe Annual Report 2013*, University of Zimbabwe

World Bank, (2010), *Reform and Regional Integration of Professional Services in East Africa: Time for Action*, World Bank Report No. 57672-AFR