Chapter 3

Recent Developments in Biomedical Engineering Education in Africa: A Focus on Nigeria and the University of Ibadan

A. Coker, F. Akintayo, C. Achi,
M. Odeniyi, A. Olorunnisola & D. Akano

Introduction

Biomedical engineering (BME) programmes are relatively few in Africa. It was reported in 2008 that only twelve African universities in only six countries offered biomedical engineering compared with 229 universities in North America (Abu-Faraj, 2008). As at 2015, there was less than 0.01 biomedical engineer per 10,000 population in Ghana compared to 0.49 in the United States (Mohedas et al., 2015).

It is evident that developing a critical mass of home-grown BME practitioners – biomedical equipment technicians, clinical engineers and biomedical engineers, all of whom have major roles to play in supporting healthcare delivery – is a prerequisite to improved healthcare delivery in Africa. One of the objectives of a BME programme in Africa should be to contribute to capacity development in this specific sub-sector of Africa's healthcare sector. It is necessary and very desirable to develop a cohort of Africans with the technical expertise to develop and manage processes and products to serve the particular healthcare needs of the continent. Another objective should be the promotion of BME research and innovation. To this end, a special focus must be placed on postgraduate research training.

This chapter provides an overview of initiatives in support of BME education in Africa as well as an overview of BME in Nigeria, with particular reference to the antecedents and features of the recently established BME training programme at the University of Ibadan. This programme was designed to develop a skilled workforce capable of creating new biomedical industries and providing solutions to emerging local and global healthcare challenges.

Initiatives to address the dearth of BME practitioners in Africa

Biomedical and clinical engineers are critical in facilitating the local design, development and production of health technologies in Africa. A number of initiatives have been introduced across Africa to address the dearth of qualified BME practitioners on the continent. These are discussed below.

BME degree programmes

Biomedical engineering degree programmes are growing in Africa. Within the past one and a half decades, a number of new BME degree programmes have been established in many universities in sub-Saharan Africa, including Addis Ababa University, Ethiopia; Kenyatta

DOI: http://dx.doi.org/10.15641/0-7992-2544-0
https://openbooks.uct.ac.za/bmeafrica

University and Technical University of Mombasa in Kenya; Makerere University and Mbarara University of Science and Technology in Uganda; Dar-es-Salaam Institute of Technology, Tanzania; the University of Ghana and All Nations University College in Ghana; Universities of Ilorin, Ibadan and Lagos, and Bells University, Ota, all in Nigeria. These programmes, the majority of which are at the undergraduate level, were established largely for the purpose of responding to the needs of the respective countries for technical expertise related to hospital equipment and its management.

African Biomedical Engineering Consortium

A consortium of African universities running, or aspiring to establish, BME degree programmes, founded the African Biomedical Engineering Consortium (ABEC) in August 2012[1]. Specifically, the goals of ABEC are to "build the human capital needed to install, maintain and upgrade medical equipment" and to "nurture entrepreneurial and innovative skills to design and develop robust and commercially viable medical devices". The Universities of Lagos and Ibadan, both located in Nigeria, were accepted as members of ABEC at the annual meeting of the consortium in Addis Ababa in January 2016.

One of the achievements of ABEC is the development of a generic undergraduate BME curriculum which has been adopted, in many cases with some modifications, by some of the participating universities.

Another major achievement of ABEC is the successful organization of five successive annual Biomedical Engineering Innovators' Summer School (ISS) events with participation of member institutions, and hosted by a different member institution each year[2]. The ISS is an initiative of the United Nations Economic Commission for Africa (UNECA) that is "aimed at fostering the economic development of Africa by stimulating biomedical innovation and improving higher education". BME students identify a problem that affects health delivery within their country and design a solution to be presented at the ISS after a competitive selection process.

Each ISS is focused on a specific area of need critical for the development of BME skills in Africa. An exploratory ISS was held in 2012; ISS 2013 introduced students to medical device regulation and rapid prototyping; and ISS 2014 had the objective of designing a simple device and exposing students to product development, business planning and marketing (Ahluwalia et al., 2015). The theme of ISS 2015 was the application of mobile telephony in the design of medical devices, while the ISS 2016 had the theme of biomedical and clinical data and informatics.

[1] http://abec-africa.org/about-us/
[2] http://abec-africa.org/innovators-summer-schools/

BME in Nigeria

Nigeria has a well-structured healthcare delivery system comprising primary, secondary and tertiary healthcare institutions. Healthcare provision in the country is a concurrent responsibility of the three tiers of government, i.e., the federal, state and local government. The federal government's role is mostly limited to coordinating the affairs of the university teaching hospitals and federal medical centres (tertiary healthcare), while the state government manages the various general hospitals (secondary healthcare), and the focus of the local government is on dispensaries (primary healthcare), which are regulated by the federal government. Private providers of healthcare also play a visible role in healthcare delivery. However, like with many other countries in Sub-Saharan Africa, Nigeria's healthcare system relies heavily on imported medical devices some of which are not well suited to the tropical environment. It is apposite to note that the major areas of BME practice in Nigeria and many other African countries are in the maintenance, procurement or sale of hospital equipment.

BME practice is not new in the country. Many Nigerians have received training and pursued rewarding careers in diverse areas related to BME for several decades as a result of coordinated efforts between engineers, physicians, pharmacists, physicists and other scientists to fill the gap. Such informal collaboration has been on-going since the 1970s, and attempts to develop training programmes have often failed. The first BME Department in Nigeria was established as a BME Unit in the College of Medicine, University of Lagos, in collaboration with the University of Liverpool in 1974. The Unit was also equipped with facilities for medical diagnosis and research. It was primarily responsible for the repair and maintenance of medical equipment, facilities and installations but was also engaged in training biomedical technologists. The Unit became a full-fledged academic department in 2009, which has introduced postgraduate and undergraduate programmes.

In another positive development, the General Electric (GE) Foundation, in conjunction with the Developing World Healthcare Technology Laboratory at Duke University and Engineering World Health, set up a Biomedical Equipment Technician Training programme at the Federal School of Biomedical Engineering Technology at the Lagos University Teaching Hospital (LUTH), in 2014[3]. The grant programme expands on the achievements of BMET programmes effectively executed in Rwanda, Ghana, Cambodia and Honduras[4].

BME in Nigeria has also been strengthened by the activities of a professional organisation. The Nigerian Institute for Biomedical Engineering (NIBE), a non-governmental organisation representing the biomedical engineering and technology profession and its members in Nigeria and in international organisations, was established in 1999 with the goal of evolving standard and enduring biomedical engineering education, training and practice in Nigeria. It currently

[3] http://www.ewh.org/2017-07-12-15-08-39/bmet-training/locations/nigeria
[4] http://www.ewh.org/contact-form/34-programs/bmet/26-bmet-training-program

has members numbering over 5,000, from the clinical setting, academia, industry, research and training, and the government[5].

NIBE introduced an annual biomedical engineering conference in 2000. The impact of the conferences on biomedical engineering training in Nigeria was consolidated when NIBE introduced an annual professional development course in 2002 to update members and qualify them as biomedical engineering professionals. The conference and professional development course have been offered every year since inception.

BME education at the University of Ibadan

Established in 1948 as a College of the University of London and transformed into an independent University in 1962, the University of Ibadan (UI) is the oldest university in Nigeria. It is a conventional and comprehensive University noted for excellence in different fields of study including Liberal Arts, Medicine, Basic Sciences, Education, Engineering, Law, Agriculture and Forestry. It is located in south-western Nigeria, 128 km inland northeast of Lagos in Ibadan the third largest metropolitan area in Nigeria, which literally means 'the town at the junction of the savannah and the forest'.

UI has established itself as a leader in postgraduate education and training in Nigeria and Africa. The University has experience spanning over six decades in administering Master's degree programmes. A number of academic departments in the University have, over the years, conducted BME-related teaching and research activities in areas such as Radiation and Health Physics, Biomathematics, Computational Biology, Genetics, Cell and Molecular Biology, Data Mining and Machine Learning, Drug formulation and delivery systems, Imaging, Microelectronics, Data Encryption, Pattern and Face Recognition Systems, Modelling of Bio-transportation Processes, Biomechanics, and development of prosthetic devices.

In December 2010, the Vice-Chancellor of UI, Professor I.F. Adewole, now the Minister for Health in Nigeria, expressed a desire for the establishment of a BME programme at UI. Hence, in January 2011 an *ad hoc* committee was set up to prepare the curriculum for a Master's degree programme in BME. In September 2013, a grant for "Developing Innovative Interdisciplinary Biomedical Engineering Programs in Africa" was awarded by the Fogarty International Center of the National Institutes of Health in the USA to Northwestern University, the University of Lagos, the University of Cape Town, and UI. The activities of this grant gave fresh insights which led to a re-drafting of the curriculum which was approved by relevant organs in UI in the last quarter of 2016.

The University of Ibadan subsequently commenced a graduate programme in biomedical engineering in 2017. Interdisciplinary capacity development for the programme was facilitated by the NIH-Fogarty grant. The 2-year Master's degree programme was designed to develop a cohort of graduates with the technical expertise to manage and develop processes and products

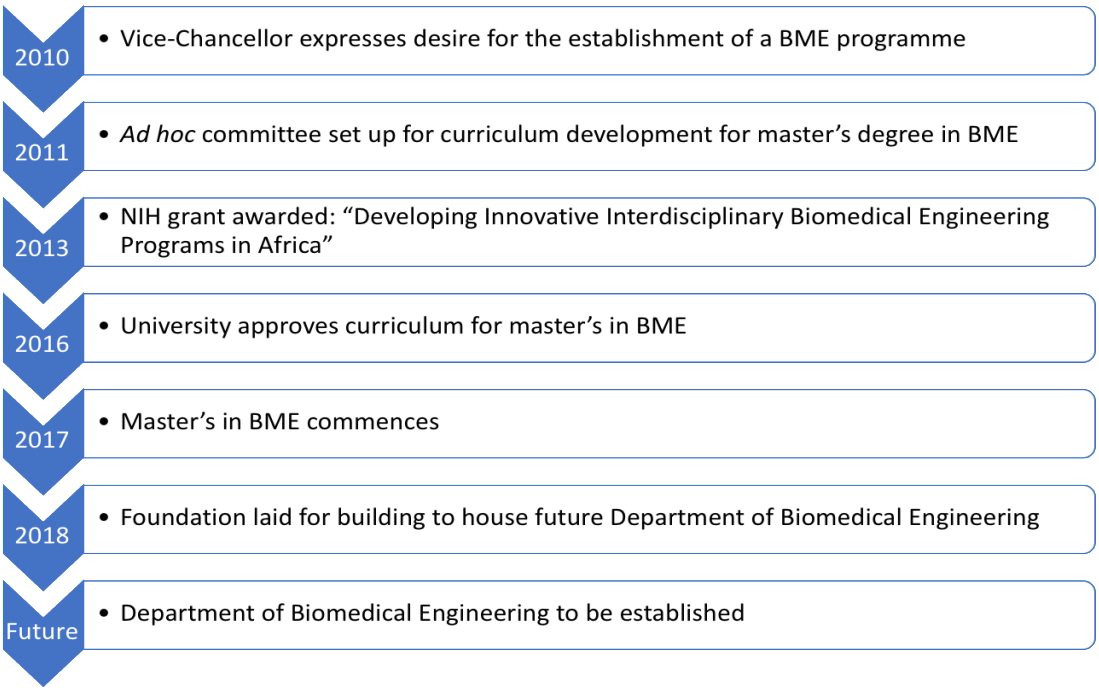
[5] http://www.nigerianbme.org

to serve the particular healthcare needs of Nigeria. The objectives of the programme are to:

- offer courses that will lead to the award of a Certificate, a Diploma and a Master's degree;
- provide students with a broad and flexible education in engineering, biological science and medically-related fields; and
- provide training and develop skills in innovation, creativity, adaptability, and critical thinking to solve problems in the biomedical industry.

The programme is currently domiciled in the Department of Mechanical Engineering, Faculty of Technology, until a fully-fledged Biomedical Engineering Department can stand on her feet. The core areas of specialisation, intended to qualify graduates for positions in healthcare facilities, universities, government, or private industry, are biomechanics, clinical engineering and biomedical materials. The programme is intended to attract students from all over Africa, including those who need basic knowledge of BME (an Advanced Certificate obtainable within one semester); those practising BME or who are in related fields and need to enrich their knowledge of BME (an Advanced Diploma obtainable within two semesters); and those that may have obtained tertiary training in related fields and are desirous of furthering their career (a Master's degree obtainable within four semesters).The first cohort of students, whose educational backgrounds were either Mechanical or Electrical & Electronic Engineering, comprised sixteen students. Course delivery is by lectures, tutorials, laboratory/workshop practicals and internships.

The timeline for the development of the BME programme at the University of Ibadan is shown below. In 2018, the foundation was laid for the building that will house the Department of Biomedical Engineering.



Timeline for development of BME programme at the University of Ibadan.

Many African universities have concentrated on undergraduate training in BME, providing a potential pool of applicants for the Master's degree programme at UI. A recent survey of the BME graduates in Ghana by Mohedas et al. (2015) showed that the labour market may not be fully ready for the quantum of graduates from the existing undergraduate programmes. An expert group meeting on promoting undergraduate BME innovation for improved healthcare in Ethiopia in January 2016, organised by UNECA in conjunction with ABEC and Addis Ababa University, indicated that the labour market was ill prepared for full engagement of BME graduates. As such, the higher degree programmes at UI provide an opportunity to absorb some of the BME graduates from across the continent and direct their attention and energy to research and development.

Impact of the NIH-Fogarty grant

The NIH-Fogarty grant made it possible for no less than 15 academic staff of UI who teach on the BME programme to visit universities abroad, particularly Northwestern University and the University of Cape Town. The purpose of these visits was to observe teaching and research activities at established BME programmes; to interact with BME faculty and possibly establish mutually beneficial research collaborations; and to audit BME classes, for example in design. These activities served to enhance BME teaching and research activities in the new graduate BME program at UI.

The grant changed the dynamics of interactions between academics in the biomedical and engineering departments at UI. Prior to implementation of the grant, academics in different disciplines were operating largely in silos. However, the opportunity to observe the fruits of collaboration at other institutions with well-established BME programmes, has led to a shift in the mindset of the UI academics who participated in training visits to Northwestern and Cape Town. In addition to collaborations to teach courses and supervise students' dissertations in the BME Master's degree programme, collaborative research activities have been proposed or are in progress. One of the impacts of the new dynamics is that BME working groups have now been established in UI and a number of research and innovation activities have emanated from these.

Conclusion

Biomedical engineering is still in the developmental stages in Africa in general and in Nigeria in particular. However, the need for the development biomedical engineering education has been identified in order to prepare middle and high-level skills in biomedical engineering and technology. As a result, a number of African and Nigerian universities have created various initiatives aimed at promoting biomedical engineering practice. One of the core initiatives is the establishment of degree programmes, mostly undergraduate, in biomedical engineering. The University of Ibadan started a postgraduate programme in biomedical engineering in 2017. One of the stated goals of the programme is to provide the participants with training and skills leading to innovation, inventiveness, flexibility, and critical thinking with the aim of solving problems in the biomedical industry, medicine, academia, and consulting. The expanding

acknowledgment of a felt need to develop health technology locally and the expanding joint effort between African and international institutions bode well for biomedical engineering in Africa.

References

Abu-Faraj, Z.O. 2008. Project Alexander the Great: a study on the world proliferation of bioengineering/biomedical engineering education. *2008 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. Vancouver, Canada. 2873–2876. DOI: 10.1109/EMBC.2008.4649802.

Ahluwalia, A., Atwine, D., De Maria, C., Ibingira, C., Kipkorir, E., Kiros, F., Madete, J., Mazzei, D., et al. 2015. Open biomedical engineering education in Africa. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. Milan, Italy. 3687–3690. DOI: 10.1109/EMBC.2015.7319193.

Mohedas, I., Kaufmann, E.E., Daly, S.R. & H. Sienko. 2015. Ghanaian undergraduate biomedical engineering students' perception of their discipline and career opportunities. *Global Journal of Engineering Education*. 17(1): 34–41. Available: http://dalyresearch.engin.umich.edu/wp-content/uploads/sites/237/2018/02/Mohedas-Kaufmann-Daly-Sienko-Ghanaian-undergraduate-biomedical-engineering-students-perceptions-of-their-discipline-and-career-opportunities.pdf. [2019, May 6].