



**NATIONAL STAKEHOLDER PERSPECTIVES ON THE
DEVELOPMENT OF THE REGIONAL CENTRE OF EXCELLENCE
FOR BIOMEDICAL ENGINEERING AND eHEALTH
(CEBE)**

A Dissertation Submitted in Partial Fulfilment of the Degree of Master of Public
Health

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DEDICATION

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*To the unborn creators and innovators who will find inspiration at CEBE to
serve humanity for better health*

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ABBREVIATIONS AND ACRONYMS

- AfDB – African Development Bank
- BME – Biomedical Engineering
- BMET – Biomedical Engineering Technologists
- CEBE – Centre of Excellence for Biomedical Engineering and eHealth
- CoE – Centre of Excellence
- EAC – East African Community
- IPRC - Integrated Polytechnic Regional Centre
- ISPO - International Society for Prosthetics and Orthotics
- MIFOTRA – Ministry of Public Service and Labour
- MINEDUC – Ministry of Education
- MoH – Ministry of Health
- NCST – National Commission of Science and Technology
- OT – Occupational Therapy
- PCU – Project Coordination Unit
- PSC – Project Steering Committee
- P&O – Prosthetic and Orthotic
- PT – Physical Therapy
- RBC – Rwanda Biomedical Centre
- R&D – Research and Development
- UR – University of Rwanda
- WCPT - World Confederation for Physical Therapy
- WFOT - World Federation of Occupational Therapists

ABSTRACT

Centres of Excellence by definition are expected to provide leadership, best practices, training and research in particular focus areas and act as coordinating entities that ensure certain innovations or services are delivered and implemented with the highest level of excellence. Rwanda, through the University of Rwanda, is developing a Centre of Excellence in Biomedical Engineering and eHealth (CEBE) to be a regional training, research and development (R&D), innovation and service delivery centre. This study explores the centre's national stakeholder's views and perceptions and recommends activities and strategies for its development.

This study used the directed qualitative content analysis technique – a qualitative study design - to identify themes from the views of 37 CEBE stakeholders coming from multiple public and private institutions in the health and education sector. These views were then analysed and compared to other scientific literature. The following common themes were identified and discussed: 1) Workforce planning, 2) Connections, 3) Availability of qualified, skilled and knowledgeable academics, 4) Training, 5) Facilities and resources, 6) Remuneration and retention, 7) Awareness and, 8) Scope and evaluate. Under business opportunities, the following themes were identified: 1) Tuition fees, 2) User-fees, 3) Research grants, 4) Consultancy services, 5) Clinical Services, 6) Patenting new products and designs.

In conclusion, for CEBE to realize this ambitious impact, it needs to develop in phases, by first ensuring its workforce is properly planned and that its programs and facilities are developed to adequately respond to the competency needs of the future. As a long term sustainability strategy, the centre should partner with reputable research organizations and industry companies in building local and regional staff capacity in training and research, offering services, developing new prototypes and products to address healthcare challenges for individual patients and the general healthcare delivery system.

INTRODUCTION

Healthcare provision is globally facing challenging times and there seems to be significant divergence between the healthcare industry's current set up, and the needs of patients and their economic situations. Many health system set ups are not addressing the challenges of rising costs, poor access, inequitable care and dropping quality and safety (1). For low-resource countries, there exists additional burdens due to a huge shortage of skilled healthcare personnel, compounded by poor retention capabilities and low investments in healthcare, thus making quality and accessibility of healthcare a major challenge (1).

For example, the developing world spends way less on healthcare as compared to developed countries. A majority of sub-Saharan countries are spending between \$15 - \$45 per capita on their health ministries and departments as compared to the USA which spends approximately \$5,274. This translates to lower investments in healthcare technology and therefore limited healthcare access (2).

As more countries acknowledge health as a human rights issue, there is now considerable emphasis on making healthcare *affordable, accessible, acceptable, equitable* and of the *high quality* (3).

The government of Rwanda, through the University of Rwanda (UR), has embarked on an ambitious journey of developing a cluster-based training, research, development and innovation **East African Centre of Excellence for Biomedical Engineering and eHealth (CEBE)** to reform health care and health care delivery in Rwanda and the region. This is with funding from the Africa Development Bank (AfDB).

According to the CEBE project document developed by the AfDB, this Centre has the objective of contributing towards the *development of a relevant and highly skilled workforce in biomedical engineering, rehabilitation and mobility sciences and eHealth, to meet East African Community (EAC) immediate labour market needs* (4). The centre is expected to do this by delivering quality and relevant skills development, research and service delivery. The intended outcome that the EAC region can become competitive in the world through a highly skilled workforce that can help deliver specialised services that are needed for the region's rapid economic development.

A Centre of Excellence is defined as *an entity that provides leadership, best practices, training and research* in a focus area; which could either be a specific subject area, a technology, or a skill (5). CoEs are also seen as coordinating entities that ensure certain innovations or services are delivered/ implemented with the highest level of excellence and in a standardized process, often by bringing together competent staff to work collaboratively (6).

CEBE is being developed in a phased approach and to set-off its development, the Ministry of Education, the executing agency, and the University of Rwanda, the implementing agency, set up the structures for implementation. This included setting up multi-institutional Project Steering Committee (PSC) as well as a Project Coordination Unit (PCU) which is based at UR. The University is expected to develop this centre by ensuring that it develops and delivers high-level training programs with qualified staff, as well as create collaborations with ‘world-class’ centres to support R&D and program delivery. Also, UR is expected to work with other public and private agencies in Rwanda and the region in developing innovation solutions and enhancing service delivery (4).

To fulfil CEBE’s stated objectives, the University of Rwanda through the PCU wishes, in these early project stages, to develop well informed and specific implementation strategies for the development of CEBE’s training, R&D and service delivery initiatives. These strategies are to inform how CEBE can be a multi-sectoral collaborative centre that pushes the boundaries of knowledge and innovation, as well as be self sustaining. According to research, stakeholder involvement, executive support, clear project objectives and experienced project management all increase the likelihood of a projects success by 65% (7). Also, appropriate, timely and consistent engagement of stakeholders, especially users and managers does influence a projects success (8).

This study analyses views and perspectives of the CEBE national stakeholders as regards how CEBE should respond to meet the training, R&D and support services needs of the healthcare sector in biomedical engineering, rehabilitation and mobility sciences and eHealth program areas. Also, this study discusses the proposed strategies and concludes with comments and recommendations arising from the work of the participants.

PROBLEM STATEMENT

The government of Rwanda has received funding to develop an ambitious training, R&D and service Centre of Excellence in Biomedical Engineering and eHealth (CEBE). The stated vision of the centre is to: *“To build a critical mass of a qualified and transferable workforce to sustainably boost the Biomedical sector with competent technical support skills, innovation and R&D capabilities, while putting in place a conducive environment for the development of a vibrant and dynamic service industry (4).”*

Rwanda faces challenges in the management and maintenance of medical equipment in the health sector that include personnel shortages of qualified biomedical engineers and technicians (9), limited skills to manage sophisticated equipment, non-standardized approaches towards procurement of medical equipment causing disparate medical equipment brands within hospitals and inadequate funding (10). Also, there is no national quality control system for the equipment (10). The ‘persistent lack of basic equipment and supplies’ is an

often neglected but major contributor to the loss of trained professionals in the health sector brain drain (11).

E-health system implementation also faces unique challenges, including expensive licence renewals, supplier driven systems and a lack of satisfactory local capacity building to continuously customize and maintain the systems (10).

Centres of Excellence by definition are expected to lead in offering best practices, training and research in particular focus areas and act as coordinating entities that ensure certain innovations or services are delivered and implemented with the highest level of excellence (5). Often, these centres are successful if they operate in an ecosystem that provides financial investments and a nexus of knowledge and expertise with a corresponding entrepreneurial culture (12).

If CEBE does not develop in such a way it is able to bring positive outcomes in health service delivery by *reducing patient risk* by ensuring availability of functional, cost-effective and nationally accessible medical equipment, devices and technologies (3,13), it may lead to continued low healthcare quality, poorer patient outcomes, low quality of life due to persistent morbidities, and a non cost-effective healthcare system among other negative impacts.

If CEBE is developed under a poorly informed implementation strategy, it would make it less effective in achieving its intended impact in improving efficiency, affordability and quality of healthcare service delivery, and consequently - a socio-economically less competitive EAC region. The population stands to benefit from broad stakeholder consultations to better design CEBE's implementation strategies and activities in a manner that responds to the real sector needs. Understanding and implementing key stakeholder perspectives and expectations of CEBE is an important part of ensuring the Centre achieves success and intended impact in the health sector.

RESEARCH QUESTIONS AND OBJECTIVES

RESEARCH QUESTION

To better understand the CEBE stakeholder perceptions and expectations, focus group discussions were conducted to respond to the following questions:

- What do the stakeholders understand by the Biomedical Engineering, Rehabilitation and Mobility Sciences and eHealth
- What are the stakeholder perceptions of the Centres training, R&D, and service delivery activities
- What are the stakeholder perceptions on the potential business activities and required facilities

GENERAL OBJECTIVE

To get a better understanding of stakeholder perceptions of the upcoming CEBE

SPECIFIC OBJECTIVES

1. To explore stakeholders understanding of biomedical engineering, rehabilitation and mobility sciences, and health information technology.
2. To explore stakeholder views and ideas on the specific training, R&D and service delivery activities that CEBE implementers should develop
3. To document stakeholder views and ideas on what functional and physical requirements of CEBE should be.

METHODS

STUDY DESIGN

This is a qualitative descriptive study that uses focus groups as a method of collecting data. This study uses an *inductive* research framework where it seeks to accumulate data to add onto an existing body of information on building CEBE up, layer upon layer. Focus group discussions are ideal for formative stages of research where little is known, and the goal is to explore views and insights of participants. The group dynamics also help to generate new insights and perspectives as well as clarify and challenge data collected through other methods (14). CEBE being a new and unique initiative in the health sector – and by the fact it is being modelled to be a multi-disciplinary and collaborative centre where no one group fully dominates the knowledge, focus group discussions helped explore these thoughts and expectations in the field and among stakeholders.

STUDY SITE AND PARTICIPANTS

Professionals from organisations providing biomedical engineering, rehabilitation and mobility and ehealth services in Rwanda (see box 1) were invited to participate in one of four discussion groups (biomedical engineering, rehabilitation and mobility sciences and ehealth) depending on professional background. With consultations, a purposeful sample of professionals interested in participating was identified. A total of 37 professionals (19 from Biomedical engineering working group, 10 from Rehabilitation and Mobility Sciences and eight from eHealth) participated.

1. University of Rwanda, College of Science and Technology
2. University of Rwanda, College of Medicine and Health Sciences
3. Rwanda Biomedical Centre/Medical Technology and Infrastructure (MTI) division,
4. Ministry of Health, Rwanda
5. Ministry of Education, Rwanda
6. National Commission for Science and Technology
7. Kibagabaga Hospital, Kigali
8. University Teaching Hospital, Kigali
9. HVP Gatagara (private rehabilitation clinic);
10. Integrated Polytechnic Regional Centre, Kicukiro (IPRC)
11. Rwanda Development Board,
12. kLab, Rwanda (Open Space for IT entrepreneurs)
13. Fablab, Rwanda (A fabrication lab)
14. Management Sciences for Health (MSH)
15. Belgian Technical Cooperation (BTC)
16. Partners in Health (PiH)
17. Other participants in private practice

Box 1. Source of participants

PARTICIPANT CHARACTERISTICS

Four focus group discussions were constituted based on the participants' professional fields based on the 3 programs of the centre (Table 1). They were invited based on the level of expected involvement of their institutions in the work of the Centre, public or private. Also, it was a purposive selection whereby some of the identified members helped identify other key stakeholders.

DISCUSSION GUIDE

A discussion group 'topics for discussion' guide was developed in consultation with members of the CEBE Project Coordination Unit (PCU) and the guide was reviewed by a honorary research fellow from the University of Glasgow. The following categories were included in the discussion group guide: **(1) definition of the speciality (2) strengths, weaknesses, opportunities and threats of current programs and services, (3) vision of the CEBE, (4) potential partnerships (5) physical resources required.**

DATA COLLECTION/ INSTRUMENTS

Discussion groups were moderated by four moderators, that is, the three CEBE programme leads for Biomedical Engineering, Rehabilitation and Mobility Sciences, and eHealth programs and the project coordinator. Groups lasted approximately 4.5 hours with a break in between. The moderators led the focus group discussions and designated note-takers made notes on templates provided on computer. At the end of each discussion group, groups were asked to present the results of their discussion to the larger group to allow for wider group discussion. Points from wider group discussion were noted by the CEBE project coordinator. Data recorded on the Power Point templates were transferred to Microsoft Word documents to facilitate coding. The data was grouped, sorted, and cross-referenced manually

Table 1: Focus group discussion participant characteristics

FGD Group	Profession	Institution Type	Number of participants
Biomedical Engineering (Group 1)	Biomedical Engineers	Public	3
		Private	3
	Electrical and Electronics Engineers	Public	2
		Private	0
	Biomedical Laboratory Scientist	Public	1
		Private	0
	Medical Doctors	Public	1
		Private	1
Sub-total			11
Biomedical Engineering (Group 2)	Biomedical Engineers	Public	3
		Private	2
	Electrical and Electronics Engineers	Public	2
		Private	0
	Medical Doctors	Public	1
		Private	0
Sub-total			8
Rehabilitation and Mobility Sciences	Prosthetic and Orthotic Technicians	Public	3
		Private	2
	Physiotherapists	Public	3
		Private	1
	Occupational therapist	Public	1
		Private	0
Sub-total			10
eHealth	eHealth system specialist	Public	1
		Private	0
	ICT specialists	Public	4
		Private	3
Sub-total			8
Total			37

ANALYSIS

The **directed qualitative content analysis** technique (15) was used to categorize and interpret textual data collected from the groups by two analysts (the CEBE project coordinator and the honorary research fellow from University of Glasgow). Before the initial identification of codes from textual data, the directed qualitative analysis method starts by setting out some theories or framework to provide guidance for identification and eventual interpretation of meaning. In the case of this study, the guiding framework was the *triple-helix* partnership model (16), which is the chosen framework the Centre of Excellence is expected to structure itself under.

The triple helix approach is a knowledge infrastructure model first proposed by Leydesdorff and Etzkowitz (17) as a complex but critical partnership between University-Industry-Government to achieve economic success through knowledge production and supporting governance. This model also seeks to introduce new institutional and social formats that can streamline within an education value chain - a culture of innovation that can lead to economic development through a knowledge-based society (18).

In the case of CEBE, the hope is that this model can help foster: a demand driven education system, increased productivity through real-time knowledge transfer, promotion of both problem-solving and creative synergies as well as economies of scale through infrastructure and human capital sharing between involved sectors (4,16,17).

ETHICS STATEMENT

This study was based on the analysis of data collected during a stakeholders' workshop organised as part of routine project implementation activities of CEBE, and therefore ethical clearance was not sought. The objective of collecting the data was to inform the design of the centre which will be a service delivery entity in the health sector. Participants were aware before the workshop that their views would support the Centres development and would be presented in a report.

To protect participants, data in this thesis report are anonymized and are not expected to cause any substantial damage or distress to any individual, department or institution. Also, to address any challenges, before any scientific publication is done, the author will seek informed consent from participants.

RESULTS

DEFINITIONS

The different FGD groups were asked to define the particular fields as they understand them. Participants offered definitions that broadly capture the fields' description in literature. The rehabilitation group went further to describe some professional groups such as physiotherapists, occupational therapists, orthopaedic surgeons etc involved in rehabilitation and mobility activities.

Definitions of specialities are presented below.

Participants of the **Biomedical Engineering group one**, defined the field as follows:

“Biomedical Engineering is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic). This field seeks to close the gap between engineering and medicine, combining the design and problem solving skills of engineering with medical and biological sciences to advance health care treatment, including diagnosis, monitoring, and therapy.”

This definition implies the nexus between the two fields of engineering and medicine and a focus on solving issues.

Participants of the **Biomedical engineering group two** defined the field as follows:

“Biomedical engineering is the field that brings together engineering specialities and healthcare provision where the practitioners work with doctors and other professionals to create, improve or repair equipment, devices or systems used in clinical care.”

Participants of the **rehabilitation and mobility sciences group** defined the field as follows:

“The ideal definition of Rehabilitation is to restore the something in its original state. In the context of health care, is to improve, maintaining and restore health status/function of a person's physical, cognition and mobility to the maximal functional independence. Rehabilitation and mobility team consists mainly of P&O, Physical therapy, OT, Orthopaedic surgeons, Neurologist.”

Again, this definition seems to encompass a wide approach to rehabilitation of an individual's healthcare, also it involves a number of healthcare professionals just as in biomedical engineering.

The **eHealth group** defined the field as follows:

“eHealth is the use of information and communications technologies to provide and support healthcare service delivery.”

This implies that all the ICT technologies are at the health professional's disposal to improve how healthcare is delivered.

THEMES ON TRAINING, R&D AND SERVICE DELIVERY

Themes arising from the stakeholders presentations are shown in 8 categories (Table 2):
1) Workforce planning, 2) Connections, 3) Availability of qualified, skilled and knowledgeable academics, 4) Training, 5) Remuneration and retention, 6) Awareness and, 7) Scope and evaluate 8) Business Opportunities

Table 2: **Summary of Themes and Sub-themes**

No.	Category	Theme
1a.	Shortage of qualified biomedical engineers	Workforce Planning: Building competencies for future needs
	Shortage of health care professionals with the right skills and knowledge on health care	
	Mismatch of demand and skills supply	
	Shortage of funding to meet the demand for qualified health information technology staff	
	Shortage of health care professionals with the right skills and knowledge in health care	
1b.	Shortage of qualified academics	Workforce Planning: CEBE
	Shortage of qualified academics (research)	
2	To meet the health information needs of the sectors	Connections
	Training	
	Partner with regional and international Academic/ research institutions	
	Industry and Government	
3	Availability of higher education courses	Availability of relevant and quality higher education
	Content of higher education courses	
	Higher education course accreditation	
4	Enhanced training opportunities	Continuous Staff Training
5	Remuneration	Remuneration and Retention of Staff
	Retention strategies	
6	Awareness	Awareness
	Advocacy	
7	Scope	Scope and Evaluate
	Evaluate	
8	Charge tuition fees	Business Opportunities
	Charge User-Fees for facilities	
	Attract research and development grants	
	Offer Consultancy (business) services	
	Offer clinical services	
	Patenting new products and designs	

1 a. Workforce Planning: Building competencies for future needs

Participants stated that there was a need to match the supply of knowledge and skills in biomedical engineering, health information technology and rehabilitation to the needs of government, health care and the industry labour market.

One of the biomedical engineers from the public sector expressed:

"There is need to better match skills and training with job market."

Another Prosthetic and Orthotic trainer from public sector expressed that:

"Some graduate prosthetics and orthotics (P&O) technicians are not being absorbed"

These responses suggest that a good workforce development plan would be achieved by working closely with government bodies, health care sector and industry to ensure real sector needs are being addressed through training.

1. b. Workforce Planning: CEBE

Participants recognised that there was a need to match the supply of knowledge and skills to the needs of the CEBE-University of Rwanda in terms of the agreed establishment numbers of teaching and academic staff with the necessary knowledge and skills to deliver higher education programmes in biomedical engineering, health information technology and rehabilitation and mobility sciences and carry out research. Participants highlighted the need for appropriately qualified, skilled and knowledgeable academic staff. Capacity, research skills and knowledge were identified as lacking across the three groups.

A biomedical engineer in the public sector expressed:

"There is need to create a department of biomedical engineering and start an undergraduate programme"

While another prosthetic and orthotic specialist in the public sector indicated that:

"There were limited qualified personnel to conduct research"

These views indicate a concern for the capacity of the University of Rwanda to deliver programs under CEBE.

2. Connections

Participants raised the importance of building connections between the CEBE-University and the world of government, health care and industry. This was seen as important to be able to provide solutions to the public sector as expressed by an e-health specialist in public sector who expressed that:

"There is limited interdisciplinary collaboration to develop effective e-health solutions"

Also, industry and university connections were seen as important for training and innovation support. A biomedical engineer from private sector indicated that:

“There is need to partner with international universities for staff and student exchange”

For CEBE to be innovative and be productive, one BME from public sector noted:

“It is important to form partnerships with manufacturers”

These views suggest that building a robust centre requires wide and strategic partnerships with institutions further ahead in the process.

3. Availability of relevant and quality higher education

Participants stated the need to provide relevant and quality higher education (university) programmes in biomedical engineering and health informatics. Internships and practical training were recognised as important training elements in health information technology programmes. An e-health specialist in the public sector indicated:

“There is limited practical training and many courses were theoretical and no internship and work experience.”

It was also stated that the College of Medicine and Health Sciences already provides some higher education courses accredited by international accreditation organisations.

4. Continuous Staff Training

Provision of ongoing training opportunities for academic staff was raised as an important issue for academic staff.

A physiotherapist in public sector expressed:

“Short trainings are necessary to provide skills for R&D”

These sentiments suggest the desire for current staff to upgrade while still in service and therefore need support to develop career to effectively deliver programs and conduct research.

5. Remuneration and Retention of Staff

Participants highlighted the importance of remuneration of staff based on qualifications and the importance of having effective employee retention strategies. An eHealth specialist in the public sector expressed:

“We lack of staff retention strategies within ehealth sector”

This remark suggests that there is risk to keep training personnel not being absorbed in the service sector.

6. Awareness

Making industry and the public aware of the work of professions under CEBE purview was seen as an important activity by participants.

A physiotherapist in the public sector expressed concern:

"There is a general narrow view and insufficient awareness of rehabilitation and Mobility sciences"

This concern was mainly among rehabilitation and mobility sciences who expressed there was little understanding of that they do, especially physical therapists and occupational therapists.

7. Scope and Evaluate

Participants highlighted the need to 'scope' or carry out research work in order to be able to gather data that would deliver services, products or results with particular and appropriate features and functions. Participants also highlighted the need evaluate investment proposals and service evaluation. A physical therapist from public sector said:

"There is a dearth of research and baseline data especially in P&O and OT"

8. Business Opportunities

The following 6 categories (Box 6.) were extracted from the participants' highlights of the main business opportunities that CEBE could develop to generate revenue and offer support services in the health sector.

1. *Charging tuition fees for training programs*
2. *Charging user-fees for use of facilities*
3. *Attracting research and development grants,*
4. *Offering Business consultancy services,*
5. *Offering Rehabilitation and Mobility clinical services*
6. *Patenting new products and designs*

Box. 6: Business Opportunities CEBE could develop

Participants recognised that the development of competitive courses would be one way of attractive some primary source of revenue at the Centre's initial stages. Also, Collaborating with other research centres/ institutions would attract funding for some investments, capacity building and overheads was pointed as an opportunity. Some of these partnering institutions with prototype projects were said could pay user fees to use CEBE facilities.

Participants, especially in the Rehabilitation and Mobility work group felt that patient services in prosthetic and orthotic services fitting, as well as physiotherapy and occupational

therapy services was an important source of revenue and way to have the Centre be in close contact with patients for the benefit of training and research.

A Physiotherapist in public sector remarked on the clinical services:

“There is need to establish the model for service delivery (PT, P&O and OT Services) through development of a clinic to deliver specialized services.”

Business consultancy services especially to the public health sector as well as private were pointed as an opportunity for CEBE when maturing in capacity. Participants indicated feasibility studies to create joint venture companies would need to be explored. Joint venture models with other institutions were seen as an option. An ICT specialist in private sector said:

“We need to design a joint company under PPP model where we provide ehealth services in MoH/RBC and other institutions”

FUNCTIONAL AND PHYSICAL REQUIREMENTS

The following categories and theme arose (Table 3) under the functional and physical requirements of the Centre.

Table 3: Categories and Theme on Functional and Physical Requirements of Centre

No.	Category	Theme
1	Lack of or inadequate facilities and resources	Facilities and Resources
	Access to patients	
	Appropriate facilities Needed	

Participants highlighted the importance of facilities, resources and services to facilitate the successful delivery of higher education courses. There was general recognition that the University of Rwanda needed to develop appropriate facilities to deliver quality training, as well as be equipped with appropriate tools and equipment, as well as spaces that facilitated collegial working. The following are the facilities identified as important for development by CEBE (box 2).

Classrooms Staff offices Medical equipment maintenance workshops Standard Prosthetic and Orthotic workshop Standard Rehabilitation rooms Laboratories Computer labs Fabrication lab Clinic: Prosthetic and Orthotic, Physio and Occupational therapy services eHealth systems collaboration spaces Rents spaces for industry Telemedicine Rooms Library of the future Student support spaces Social spaces
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Box 2. Facilities mentioned as important for CEBE

DISCUSSION

The results of this study demonstrate that there is strong desire to see CEBE develop training programs that respond to the right skills needs in the service sector areas covered by CEBE, and that its staff are capacitated to deliver high quality programs. Also, developing strategic partnerships are seen as key to being able to build a foundation and local capacity to deliver quality programs and research. CEBE having the right facilities and resources was also seen as influential to the quality of programs and innovative work anticipated to be done at the centre. Also policies that encourage staff retention are highlighted as essential for sustainability of this initiative. Finally, business development was also seen as key to the sustainability of the centre and several initiatives are suggested.

The study findings are discussed and compared to the missions of the project as found in the *Technical Annexe of the Project Appraisal Report (PAR)* (16) of CEBE as presented by the African Development Bank for Rwanda's funding.

This study found that **planning for the workforce** in the biomedical engineering, rehabilitation and mobility sciences (prosthetic and orthotic specialists) and eHealth fields so as to build competencies of the future was consistent with CEBE's stated vision in the PAR (pg. 42) of *developing a critical mass of skilled workforce by delivering demand-driven education to address the significant national and regional S&T needs in Rwanda and the region*. This workforce planning should consider systematic skills needs analysis, to allow for systematic workforce planning that would appropriately address the sector workforce challenges.

Also **work-force planning in the context of the CEBE** entity's capacity to deliver higher education programs as well as research and development was highlighted as important. All stakeholder groups were in consensus that there was 'lack' of expertise in all fields and 'weak' research capacity. CEBE's project document anticipates this need as it states *that 'The [CEBE] staff are mainly experienced scholars, researchers and professionals actively engaged in CEBE's core business process, i.e., consultancy, innovation and R&D (pg. 48)*. Also, the document states that *'The development of intellectual capacity within faculty in biomedical and related sciences makes the potential award of research grants likely' (Pg. 55)*.

Studies show that the success of an innovation system is dependent on the capability of the individuals, institutions and regions in that system to learn rapidly (19). It is therefore imperative that if CEBE is to successfully deliver in training, research and innovation, it must ensure that its staff are not only comprehensively trained and equipped, but also have a drive to continuously learn and develop. This suggests that a comprehensive academic and research staffing plan should be undertaken to draw out the gaps and areas that require capacity development support as well as outline areas that would need other type of initiatives that would boost the existing capacity of CEBE to deliver its academic programs

and research and development vision. This plan should take into consideration the factors that influence having a staff that is driven to continuously learn and improve.

This study found that **strategic connections** with other reputable academic institutions, industry companies are critical to the success of the centre's relevance in training, and research and development. Stakeholders recommended strategic partnerships be developed to facilitate staff exchanges, program development and for industry connections. This recommendation is also well cited in the PAR where it was anticipated that the centre will *“provide the necessary environment and enter into strategic win-win partnerships with renowned institutions specialized in areas of interest for the Centre so as to achieve skills transfer, knowledge exchange and professional standards [pg 50].”*

Also, according to Leydesdorff and Etzkowitz (17), strategic University-Industry-Government partnerships can foster a knowledge infrastructure model that brings new institutional and social formats that can bring about economic and market success through knowledge production and supporting governance. This is a key area that CEBE would need to strategically approach so as to position itself as a centre that can adapt flexibly in these partnerships and thus be able to reap the benefits of these types of strategic collaborations.

This study found supporting delivery of **relevant quality education** to trainees was important for the production of well trained professionals. This is well reflected in the original strategy where trainees are expected to get internships at the centre to acquire *practical knowledge and real-job experience prior to joining the labour force on concrete projects assigned to the Centre by both the public and private sectors [pg.50].*

Research shows that practical training in tertiary education is important in developing expertise in actual work (20). This mainly happens within a community of profession and influences the improvement of a student's understanding of the theoretical knowledge and their motivation for study.

This study also found that developing and equipping a modern CEBE physical complex to facilitate successful delivery of the training, R&D and business activities of the centre was considered a central feature for the centre. Of those spaces proposed by stakeholders, the eHealth program participants indicated they could in effect share most of its required spaces such as computer labs and eHealth developer open-collaboration spaces with other programs.

The proposal to develop a *rehabilitation clinic* by the rehabilitation and mobility sciences group elicited very passionate views among participants. Some members opined that that CEBE is not envisioned to be in the clinic business. The program lead for rehabilitation explained that it was important for training in skills go hand-in-hand with service provision which needed a standard prosthetic and orthotic workshop, standard physiotherapy and occupational therapy rooms and a clinic section.

In relation to services envisioned in the original design of CEBE, the PAR states that as one of CEBE's sustainability strategy there should be "*service to patients, families and communities through mobility aids and limb fitting*" [pg 60]. Also the PAR specifically addresses itself to the **prosthetic and orthotic program** under rehabilitation and mobility sciences. In specific, in the PAR it is anticipated that "*The development of a skilled workforce cannot be separated from the service delivery aspects within the Centre, and people who present themselves, or are referred, are managed in a teaching environment and the service they receive is a learning experience for the students*" [pg. 53]. These two citations give clarification as to the scope of services originally envisioned in CEBE, i.e. mainly addressing the need for CEBE to offer **prosthetic and orthotic patient-fitting services to referred patients** and serve as a training and research opportunity for the trainees.

This study found that developing appropriate **staff retention and remuneration** strategies was viewed as part of a long-term success and sustainability strategy for CEBE. Indeed CEBE in the PAR is expected "*to create jobs*" and work towards "*a retention rate of 85%*" in the concerned sectors. Central to achieving this strategy is the expectation that CEBE is developed as a highly collaborative and *commercially-driven* centre.

Indeed, studies show that research is a major source of satisfaction for academicians as well as being able to participate in the wider community of professionals (21).

Finally, this study found specific service delivery and revenue generating activities for CEBE's sustainability are also anticipated in the PAR. However general clinical services in rehabilitation and mobility specifically *physiotherapy and occupational therapy patient services*, as recommended by the rehabilitation working group are not anticipated. As stated in a previous section of this study, the CEBE project document only specifically anticipates prosthetic and orthotic patient fitting services.

LIMITATIONS

The stakeholders' workshop had two main limitations. First, groups were facilitated by the designated CEBE programme leaders who may have influenced the group discussion (i.e., introduced bias) due to their participation in the project. Also, the participants were made aware of the points of discussion in advance giving participants time to prepare, this may have made the discussions less open and more structured and therefore this report anticipates there may have been loss of some information.

The data were analyzed manually without the assistance of any qualitative data analysis software. This may potentially compromise validity and the auditability of the results(22). The purpose of this research was to gain insight on participant ideas and not on the breadth and volumes of the views, being that this is action research to support the development of CEBE.

CONCLUSION/ RECOMMENDATIONS

CONCLUSION

The national stakeholders of CEBE reported positive perceptions as to the Centre's potential to be a significant game changer in the biomedical engineering, rehabilitation and mobility and health information technology sectors by contributing to the provision of cost-effective, efficient and patient-centred healthcare. A number of approaches have been recommended for implementation as a way of ensuring CEBE truly becomes an effective and central player in the biomedical engineering industry in the region. Despite some minimal views that do not align with the purview of the Centre, stakeholders were able to share insightful strategies and suggestions for CEBE development.

Including these strategies and recommendations may lead to the development a stakeholder responsive centre of excellence with the promise of being impactful and sustainable. This study can inform other implementers of similar centres of the key areas of consideration while developing other training, R&D and service delivery centres of excellence in similar settings.

RECOMMENDATIONS

Here below is a **summary of the recommended activities and strategies** that arise from an analysis of the CEBE stakeholders' workshop findings and are being recommended for implementation as part of the development process of CEBE.

1. a) Implement a skill needs matching/ analysis for different cadres under CEBE scope as part of the CEBE programs development.
b) Develop a CEBE staffing capacity development plan to actualize the delivery of CEBE's academic, research and development mandate.
2. Enter into strategic collaborations with regional and international institutions, organisations to systematically develop 'home-grown' capacity to deliver training and R&D, as well as to support the development of industry connections.
3. Collaborate with government and industry to create opportunities for hands-on real-life project for trainees for practical and relevant training
4. Avail opportunities for continuous staff upgrading in specialisation areas through short courses and other avenues.

5. Pursue program validation locally and accreditation internationally for quality assurance
6. Develop and equip the CEBE with the following facilities:
 - i. *Medical equipment maintenance workshops*
 - ii. *Engineering Laboratories*
 - iii. *Standard prosthetic and orthotic workshop (with gait analysis)*
 - iv. *Prosthetic and Orthotic patient-fitting centre (for referred patients)*
 - v. *Computer lab*
 - vi. *Multi-media classroom*
 - vii. *Fabrication Lab (biomedical engineering and P&O equipment and devices)*
 - viii. *Classrooms*
 - ix. *Staff offices*
 - x. *A shared open-collaboration space*
 - xi. *Rents spaces for industry companies*
 - xii. *Telemedicine technology training room*
 - xiii. *Library of the future*
 - xiv. *Student support spaces*
 - xv. *Social spaces*
7. Develop CEBE as a commercial-driven centre that allows for staff development, competitive remuneration and retention
8. Organise periodical conferences, open-days, community outreaches to showcase work of these professions and do advocacy.
9. Support the development of baseline information in priority thematic areas that support CEBE implementation.
10. Further develop the following business and revenue generation opportunities:
 - i. *Generating tuition fees from competitive training programs*
 - ii. *Charging user-fees for use of CEBE laboratory/ workshop premises and equipment*
 - iii. *Applying for research and development grants for continued development and re-investment into CEBE*
 - iv. *Developing consultancy (business) services, including exploring joint venture companies with government and industry, and supporting and incubating spin-off companies*
 - v. *Developing Prosthetic and Orthotic patient-fitting services*
 - vi. *Patenting new products and designs that staff and CEBE research team innovate*

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