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Drivers and Restrainers of Relevance in Graduate BME Education – a South African study

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Abstract— **Academic biomedical engineering (BME) has the potential to address health care needs through the training of graduates able to work in and build the health care technology industry, and through the production of knowledge and research products that can be exploited to enhance health care. This paper explores factors that drive and restrain the relevance of a graduate BME program, i.e. its contribution to health care technology development and utilization, in South Africa, a middle income country with significant health disparities among its population. A focus on clinical and industrial partnerships is proposed.**

I. Introduction

Human development has been defined as a process of enlarging people's choices, by creating an enabling environment in which they can lead a long and healthy life, be educated and enjoy a decent standard of living [1]. Health is recognized as a route to development: three of the eight Millennium Development Goals involve the improvement of human health [2]. The particular developmental contribution that the academic discipline of biomedical engineering (BME) is able to make, is: to address health care needs through the training of graduates able to work in and build the health care technology industry, and through the production of knowledge and research products that can be exploited to enhance health care. The interests of industry and the health care delivery system do not always coincide, nor are they mutually exclusive. The industry wishes to make profits, while the health system aims to improve health (the public health system especially has a strong developmental role). It is assumed here that graduate programs in BME can assist both.

A large part of the health care technology industry is occupied by the medical device industry. Medical devices are the most common and diverse of the products used in health care, yet low and middle income countries have limited access to them [3]. Despite the existence of a strong engineering base and a strong clinical environment in South Africa, a middle income country with significant health disparities among its population, the medical device industry is underdeveloped here [4].

This paper explores factors that drive and restrain the contribution made by the graduate BME program at the University of Cape Town to health care technology development and utilization in South Africa, i.e. the relevance of the BME program to its local context.

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II. Methodology

A qualitative study was carried out using the grounded theory methodology, which develops explanations for phenomena based on empirical or grounded data, and enables the understanding of contextual influences [5].

The sources of data were located in the following stakeholder domains: universities; industry; clinicians; government; and funding agencies. Society is not represented explicitly in a stakeholder domain, but it is assumed that its interests are represented by other stakeholders, such as the university, clinicians and the government, who have a mandate to serve society. In the universities domain, interviews with academics concerned with citizenship education, provided a perspective on society's interests. Citizenship may refer to membership of communities and relationships between members, but also to relationships between individuals, communities and nations [6]; citizenship education is concerned with preparing students to function and effectively serve society in a complex social and political environment.

The study made use of semi-structured conversational interviews with 12 stakeholders of the health technology industry and the health system, as shown in Fig.1. The perspectives of funding agencies [7],[8], the government [9], and other entities advising the government [3]],[4],[10] were obtained from published documents. In addition, a broad range of perspectives was gathered at local conferences related to BME [11][12].

Areas of focus for the interviews were: the relationship between the different stakeholder domains; interviewees' experiences of interacting with participants of other stakeholder domains; and drivers and restrainers of health care technology development and utilization in South Africa.

Student perspectives were obtained from questionnaires that applicants to the BME program at the University of Cape Town are requested to complete on application. Twenty-two questionnaires were available from students who successfully applied to the program during the period 2009-2011. Student answers to the following questions were examined: What are your reasons for wanting to study biomedical engineering? What career path do you envisage?

Key concepts related to health care technology development and utilization were identified. A concept analysis of these revealed their interrelationships.

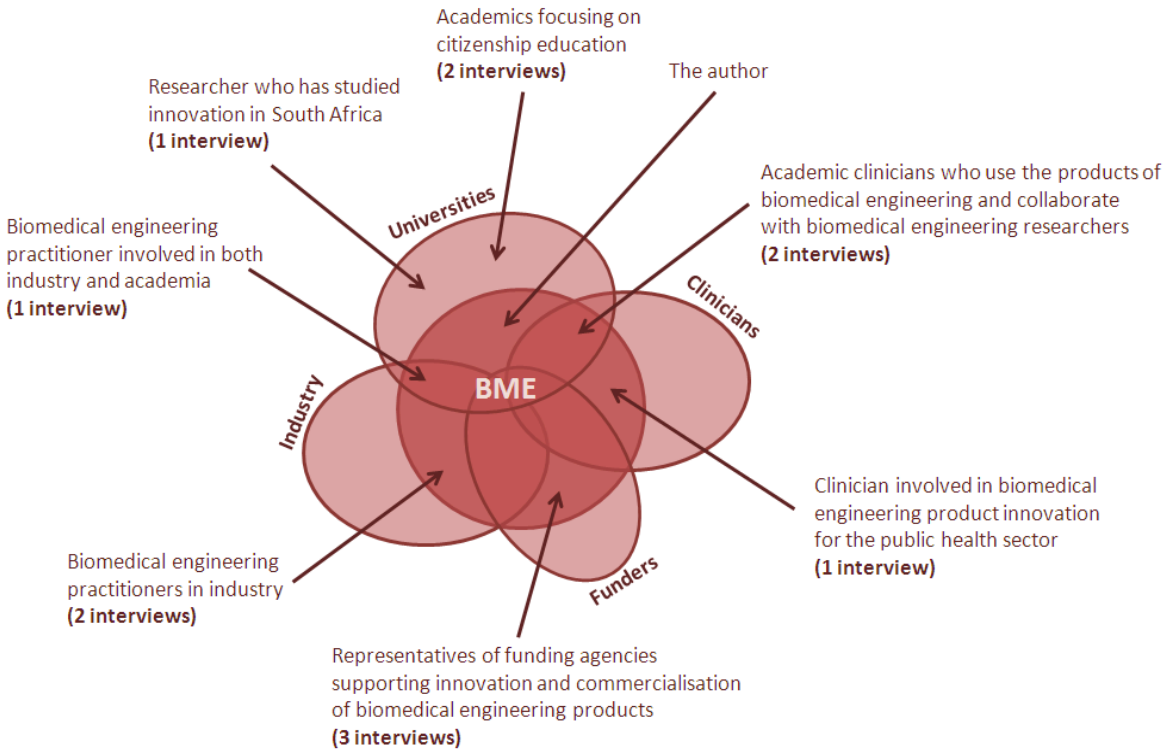

FIG 1. STUDY INTERVIEWEES AND THEIR DOMAINS.

III. Results

The following key concepts were identified during the study.

The *Traditional academic reward system* is a feature of the environment in which the biomedical engineering program operates. It represents the university requirements that academics need to meet in order to be rewarded through promotion and other forms of recognition; these requirements are primarily related to research and publication.

The *Publish-or-perish mind set* addresses the culture and beliefs of the academics who are key decision makers in the biomedical engineering program. It represents the degree of focus by academics on the production of research and publications regardless of impact on development, as well as the tendency by academics to regard postgraduate education in terms of research only, rather than as preparation of students for careers outside academia.

Attention to context addresses the relationships of the program with its external environment. It comprises the level of attention paid by students and academics to the social, political, economic, clinical and industrial context within which their research takes place.

The *Relevance of postgraduate training* represents the degree to which the academic program provides students with skills that (1) are required in the health care technology market, which comprises the industry that produces technologies and the health care system that uses them, and (2) would equip them to pursue their desired career path.

The *Utility of research products* represents the degree to which the technological products of research meet health care needs or can be developed by industry to meet health care needs.

Engagement in clinical and industrial partnerships addresses the relationships of the program with its external stakeholders. It includes the number and quality of partnerships and the extent to which an academic program is able to create mutual understanding and shared value with collaborators and partners, so that partnerships have useful and relevant outcomes.

An analysis of the above concepts is shown in Table 1. Each concept is analyzed by identifying its attributes, antecedents and consequences. Attributes are "those factors without which the concept would not exist", while antecedents include "personal and organizational factors that influence how the concept is enacted", and consequences are "the outcomes of enacting the concept" [13].

IV. Discussion

Universities seldom evaluate the relevance of their educational programs to the needs of the health care system [14]. Faculty resistance to greater contextual relevance may be attributed to concerns about promotion and tenure, which favor peer-reviewed publications over research reports and other work for industry and other external entities [15]. Conflict between educational goals and societal goals has

been found in an interdisciplinary community-based project at a South African university, with a degree of incompatibility between "elitist" institutional research culture and inflexible university bureaucracy on the one hand and external engagement on the other [16].

International university rankings play a role in institutional research culture and the academic reward system. It has been suggested that they discourage institutions from pursuing developmental goals [17]. International rankings disadvantage institutions in a country like South Africa, where empowering marginalized citizens and addressing skills shortages are priorities, because these rankings neglect models of higher education with a developmental focus [18]. Rankings reassert the hierarchy of traditional knowledge production, focusing on publications and neglecting impact beyond academic interests [19].

Thus the *Publish-or-perish mind set* and the *Traditional academic reward system* are likely to change slowly, and a BME program is unlikely to have much direct influence over them. Therefore, rather than attempting to remove these obstacles to relevance, attempts should be made to strengthen the drivers of relevance.

The concept analysis shows *Engagement in clinical & industrial partnerships* to be a driver of relevance. It is an antecedent to *Attention to context*, which in turn is an antecedent to *Relevance of postgraduate training* and *Utility of research products*. Increasing the level of *Engagement in clinical & industrial partnerships* may therefore also be expected to result in an increase in the levels of *Attention to context*, *Relevance of postgraduate training* and *Utility of research products*.

A number of benefits may be achieved through university-industry interaction in biomedical engineering education and research [20]: universities become aware of current technologies in use in industry and in response are able to prepare students to meet industry needs; universities obtain industry assistance with research projects; and new funding opportunities become available. Parallel benefits may be expected for clinical partnerships: awareness of technologies used in clinical practice; clinical input into research projects; and student familiarity with different aspects of clinical practice. In addition, researchers may be expected to become aware of industry and clinical research needs.

Study limitations

The research takes limited account of the perspectives and experiences of BME students and graduates. A mismatch between graduate attributes and industry requirements, as reported by graduates, was found in a study on Australian science, engineering and technology graduates [21]. Such a study on BME graduates in South Africa would be useful.

The study does not explore the limitations that the size and nature of the local biomedical engineering industry imposes on the provision of learning and research opportunities and graduate employment.

A more comprehensive study of the needs of the local health care technology industry and the health system would enhance the ability of biomedical engineering programs to respond to these needs.

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TABLE 1. CONCEPT ANALYSIS.

	Antecedents	Defining attributes	Consequences
Traditional academic reward system	Traditional academic culture.	Discovery as the primary goal of academic activity, expressed through publication, and rewarded through citation and professional awards.	Academic ranking and rating systems, funding mechanisms, and promotion and tenure procedures that reward publications.
Publish-or-perish mind set	Academic ranking and rating systems, funding mechanisms, and promotion and tenure procedures that reward publications.	Perception of publication as a measure of productivity. Perception of publication as a determinant of reputation. Research work targeted at academic peers.	Lack of interest in technology transfer. Lack of engagement with non-academic stakeholders.
Engagement in clinical and industrial partnerships	Interdisciplinary nature of biomedical engineering. Complexity of health care needs. Changing role of higher education.	Collaboration with industry. Collaboration with health care facilities and clinicians. Collaborative projects to address health care problems. Creating shared understanding with partners about project requirements.	Contextually relevant solutions to health care problems.
Attention to context	Engagement with the external environment (clinical, social and industrial).	Awareness of the context-dependence of health care needs. Awareness of the context--dependence of successful technology implementation.	Consideration of context in the design of health care technologies.
Relevance of postgraduate training	Health as a contributor to development. Complexity of health care needs. Needs of health care technology industry. Context-dependence of health care technology implementation.	Exposure of students to the external environment in which health technologies are needed and used. Teaching of professional skills.	Ability of graduates to contribute to the development of health care technologies and to contribute to the health care technology industry.
Utility of research products	Health as a contributor to development. Complexity of health care needs. Context-dependence of health care technology implementation.	Context-appropriate product development. Considering product implementation in product development. Responsiveness of product design to health care needs.	Suitability of health care technologies for the context in which they are to be implemented.