Abstract: The biomedical industry is booming in the Asian-Pacific region. Countries and territories in this region are providing various educational and training programmes for future biomedical engineers. However, different countries and territories have different emphases and models (or mechanisms) in training engineers for the fast-growing biomedical industry. This paper provides an overview of most, if not all, activities in biomedical engineering education and training in Hong Kong.

Introduction

Our society is changing constantly and there are new industries that require well trained and competent engineers who possess specialist knowledges. Biomedical engineering is booming in the developed as well as developing world, and there is an ever-increasing demand for university graduates well trained in engineering and life sciences.

The Hong Kong Government has declared its intention to promote biotechnology as part of the knowledge-based and high-value-added economy. Forseeing society's needs and also keeping in alignment with Government's policies recently, staff in tertiary institutions in Hong Kong have been carrying out research in biomedical engineering since decades ago and within the last decade the tertiary institutions started educational programmes in biomedical engineering. Hong Kong has its unique system for tertiary and professional education of engineers. Biomedical engineering, as everyone involved in it agrees, is a fast-expanding, intrinsically interdisciplinary field. The US and Western Europe as pioneers in the field have provided exemplary biomedical engineering educational programmes. How to learn from these programmes and thus set up their own programmes with characteristics and also distinct features for local students is a major task for biomedical engineering educators in other countries. Local situation and needs are certainly different from those in North America and Western Europe, which dictates local programmes in their major aspects, if not every aspect. This paper looks into different biomedical engineering educational programmes at various levels in Hong Kong. No attempt has been made to compare these programmes.

Biomedical Engineering Education in Hong Kong

Bachelor-degree Level Education in Biomedical Engineering

Currently, there are two universities in Hong Kong that offer Bachelor degree level education in biomedical engineering.

Biomedical engineering education at the Hong Kong Polytechnic University (PolyU) has undergone several stages of development. The BSc in Prosthetics and Orthotics (P&O) programme previously offered by the Jockey Club Rehabilitation Engineering Center (REC) of PolyU was started in 1995/6. Since its inception, the curriculum of this programme was broadened to encompass many aspects of the development and application of technologies to healthcare, and the programme was renamed BSc in Health Technology in 2000. Inside this programme, there are three concentrations: Bioengineering, Orthotics, and Prosthetics. The programme aims to provide students with the necessary training and required background in both engineering and biomedical sciences. The programme has the distinctive strength in rehabilitation engineering education. With recent developments in the University, the programme has been retitled as BSc in Biomedical Engineering for the 2005/06 student intake.

Major components of study in PolyU's BSc in Health Technology programme include: (1) foundation health studies, (2) foundation technology studies, and (3) specialty courses in respective concentrations. Foundation health studies cover anatomy, physiology, pathophysiology, orthopaedics, traumatology and rehabilitation, and holistic health care. Foundation technology studies span from applied mathematics,
computing/programming, biomechanics, bioelectrical technology, human movement analysis, to materials processing. For the Bioengineering concentration, the programme offers courses in electrophysiological instrumentation and measurements, biomaterials science and engineering, biosignal and imaging processing, transport processes in living systems, etc.

The structure of PolyU's BSc in Health Technology programme consists of 90 academic credits (including 15 compulsory credits and 15 elective credits) which are required for graduation, as well as 4 practical training credits and 420 hours of work integrated education (WIE). The academic credits include 25 credits for core biomedical engineering courses, 16 for foundation health studies, 17 for foundation technology studies, 6 for language and general education and 9 credits for independent study. With the introduction of the credit base and the major/minor systems in the University in 2002, the programme allows students to take Biomedical Engineering as their major discipline and take other disciplines such as mechanical engineering as their minor discipline. Students can also take biomedical engineering as their minor discipline.

PolyU's BSc in Health Technology with a specialism in Bioengineering went into provisional accreditation of the Hong Kong Institution of Engineers (HKIE) in March 2003. It is expected that it will gain its full accreditation in early 2005 after the recent visit by the Accreditation Team from HKIE.

For education in biomedical sciences, the Department of Rehabilitation Science at PolyU offers two Bachelor degree programmes: BSc in Physiotherapy, and BSc in Occupational Therapy.

The University of Hong Kong (HKU) has a leading medical school in the region. The Faculty of Engineering of HKU is the largest faculty of the University and is conscious of the need for a new engineering education to prepare students for the global knowledge-based economy. Both Faculties of Engineering and Medicine of HKU are committed to developing medical engineering technologies and training medical engineers. With the university support, the two Faculties launched a BEng in Medical Engineering programme in 2002. The Faculty of Engineering runs this Bachelor degree programme with strong participation from Engineering and Medicine (involving seven academic departments). Thirty percent of the curriculum is offered by the Faculty of Medicine.

The BEng in Medical Engineering programme in HKU is designed to prepare students for both professional and scientific developments in the fast-growing biomedical engineering field. It educates engineering students to use engineering principles and methods to develop medical instrumentation, diagnostic and therapeutic devices, and other technologies needed in biology and medicine. HKU’s BEng in Medical Engineering programme has attracted good quality students. The Programme has constantly ranked to be one of the top three programmes in the Faculty of Engineering in terms of the quality of student intake.

In the BEng in Medical Engineering programme in HKU, first-year students take foundation courses in engineering and medicine such as “Applied mathematics and mechanics”, “Circuit theory and digital logic design” and “Basic biochemistry”. Medical engineering courses such as “Medical imaging”, “Biomaterials” and “Thermal fluids for medical engineering” are taught in the second year. In their third year, the students continue to gain knowledge in medical engineering as well as in mechanical engineering and electrical and electronic engineering through courses such as “Transport phenomena in biological systems”, “Magnetic resonance imaging technology and applications”, “Introduction to bioinformatics”, and “Biomedical electronics and sensor systems”. The “Life sciences I, II & III” courses offered by the Faculty of Medicine run through the first and second years and Medical Engineering students are taught alongside medical school students. Through these life sciences courses, Medical Engineering students should have a firm grasp of human anatomy, biology, and physiology. The students are exposed to the industrial environment and gain their initial industrial experience when they are attached to local or overseas biomedical and healthcare companies for their industrial training during the summer term of their second year study. Students' final year projects are jointly supervised by academic staff from Faculties of Engineering and Medicine and address engineering problems in medicine. Medical Engineering students are very keen to take part in cutting-edge research. In June 2004, by submitting her project paper to the competition, a second year Medical Engineering student participating in bone analogue biomaterials research was short-listed as one of the finalists in the 16th Annual Medical and Sports Engineering Student Project Competition organised by UK's Institution of Mechanical Engineers.

In the BEng in Medical Engineering programme in HKU, there are compulsory courses, core courses and complementary studies courses. HKU also uses the credit-based system, but its credit-unit is different from that of PolyU’s. The curriculum of BEng in Medical Engineering comprises 186 credit-units of courses: (a) 23 core courses (129 credit-units); (b) 21 credit-units of elective courses; (c) 9 complementary studies courses (30 credit-units); (d) 36 Engineering Training (3 credit-units); and (e) Industrial Training (3 credit-units). To complete the degree requirement, a student must take all the courses listed under (a) to (e) and obtain at least 180 credit-units. In addition, students must pass the English and Chinese language courses (9 credit-units) and satisfy the IT Proficiency Test.

For the provisional accreditation of the BEng in Medical Engineering programme, the Accreditation Team from HKIE visited HKU in November 2004 for the on-site assessment. It is expected that the programme will gain provisional accreditation in early 2005. HKU will seek full accreditation of the programme after its first batch of Medical Engineering students have graduated.

In HKU, there is also a BSc in Bioinformatics programme which is jointly offered by the Faculties of Engineering and Medicine and led by the Faculty of Medicine.
The two Bachelor degree level biomedical engineering educational programmes offered by PolyU and HKU, respectively, have different emphases and have particular strength in different areas. Overall, they provide biomedical engineering education and training in alignment with respective university’s missions and to meet needs of the society.

**Taught Postgraduate Programmes in Biomedical Engineering**

In Hong Kong, PolyU has maintained a taught postgraduate programme in biomedical engineering, the Master of Science (MSc) / Postgraduate Diploma (PgD) in Health Technology programme, for a few years now. This programme admits part-time students having an honours degree in engineering or applied sciences, or a degree in health care discipline or related fields. Applicants with two years of relevant post-qualification experience in health care service are preferred. Students of the programme need to take core courses such as “Mechanics of living tissues and systems” and “Clinical measurements and evaluation”; and also compulsory courses such as “Concepts in health and health care” and “Research methods and data analysis”. After completing taught courses, the student conducts a research project under the supervision of a REC academic staff. With the nature of being a part-time course, students of the programme may take several years to complete their MSc study.

The Hong Kong University of Science and Technology (UST) established a Bioengineering postgraduate programme and the School of Engineering is the main school responsible for this programme at UST, with the School of Science also taking an active part. Applicants for admission to the MSc in Bioengineering programme must possess a Bachelor's degree in a relevant Engineering or Science discipline from a recognized university or an approved institution, or possess recognized professional qualifications equivalent to a degree. The Bioengineering programme at UST currently comprises four concentration streams: (1) Biological Information Engineering; (2) Bioprocessing and BioProduct Design; (3) BioMEMS and Biomaterials; and (4) Pharmaceutical Engineering.

In the MSc in Bioengineering programme at UST, students are required to complete 30 credit courses for MSc programme and 15 credits for research programmes. The courses include: (a) three core courses: “Molecular Biology for Bioengineering”, “Biochemistry for Bioengineering”, and “Cell Biology for Bioengineering”; and (b) a range of elective courses such as “Bioproduct and Processes”, “Analytical Methods for Bioengineering”, and “Molecular and Development Neurobiology”. The MSc project(s) should be within the student’s area of concentration. All projects are under the supervision of designated research affiliates in the Bioengineering Programme.

In Hong Kong, except for HKUST, no other universities offer research degree programmes specifically for biomedical engineering. However, in universities such as HKU, PolyU, the Chinese University of Hong Kong (CUHK), and the City University of Hong Kong (CityU), research students working on biomedical engineering projects are under the supervision of academic staff of departments such as Mechanical Engineering, Electronic/Electrical Engineering, Industrial Engineering, Orthopaedics and Traumatology, etc. The normal duration of study for research degree candidates in Hong Kong is: two years for Master of Philosophy (MPhil) students, and three years for Doctor of Philosophy (PhD) students.

In the Bioengineering postgraduate programme in HKUST, students can apply to study for MPhil or PhD in Bioengineering degree. Admission requirements to MPhil and PhD studies are different. HKUST now has a Consortium of Bioengineering which acts as a bioengineering research focal point within HKUST.

In HKU, there is a virtual Biomedical Engineering Research Center in the Faculty of Engineering which coordinates biomedical engineering research. Individual academic staff in traditional departments such as Electrical and Electronic Engineering and Mechanical Engineering in the Faculty of Engineering, and Department of Orthopaedics and Traumatology of the Faculty of Medicine are supervising research students and staff working in the biomedical engineering field. These research students have entered various research degree programmes by meeting HKU’s research student admission requirements and are working on biomedical engineering projects.

In CUHK, there is a Joint Research Center for Biomedical Engineering and staff in the Department of Electronic Engineering are actively conducting research in biomedical engineering with their students. Some research students’ projects in the Department of Orthopaedics and Traumatology of the Faculty of Medicine at CUHK are also bioengineering-related.

In PolyU, biomedical engineering research is mainly conducted in the REC and research students there are working on projects in biomechanics, rehabilitation technology, etc. In other universities in Hong Kong, there are groups of staff and students working on bioengineering-related projects.

**Professional Training for Biomedical Engineers**

The Hong Kong Institution of Engineers is the professional body of engineers in Hong Kong. All engineering degree programmes offered by tertiary institutions in Hong Kong should be accredited by HKIE. One of the missions of HKIE is “to maintain a high standard of the profession”. There are currently sixteen divisions in HKIE, the Biomedical Division being one of them. This division promotes the advancement of biomedical engineering in Hong Kong and facilitates the exchange of knowledge and ideas. A new discipline in Biomedical Engineering has recently been formed within HKIE, under which Continuing Professional Development (CPD) is a requirement of all
Training in Hong Kong

Outlook of Biomedical Engineering Education and biomedical engineering programmes in Hong Kong. provide industrial training places for students of the two in biomedical engineering. Association members undergraduate and postgraduate education and training with tertiary institutions in Hong Kong with regards to discipline members. The Biomedical Division regularly organises CPD seminars in biomedical engineering which are open to all HKIE members. It also arranges professional visits to hospitals and medical device manufacturers for the members. Besides, the Division organises the biennial biomedical engineering conference in Hong Kong. The Division is also responsible for setting up the Biomedical Engineering Training Scheme which graduates of biomedical engineering programmes can enter. The Training Scheme adopted by the industry, Hong Kong Hospital Authority, and the Electrical and Mechanical Services Department of the Hong Kong SAR Government provides initial professional training of biomedical engineers. Through these measures, a comprehensive, relevant, and up-to-date biomedical engineering education in Hong Kong is offered all the way up from the undergraduate level through professional career.

The Hong Kong Productivity Council (HKPC) is a multi-disciplinary organization established to promote increased productivity and the use of more efficient methods throughout Hong Kong's business sectors. As such, it assists Hong Kong's biomedical industry by providing technical assistance and continuing education of (biomedical) engineers. It also regularly organises summits, workshops and seminars in biomedical engineering which are open to the public. There are more than 140 registered medical / healthcare equipment companies in Hong Kong and the Hong Kong Medical and Healthcare Device Manufacturers Association (HKMHDMA) is their professional association. HKMHDMA interacts strongly with tertiary institutions in Hong Kong with regards to undergraduate and postgraduate education and training in biomedical engineering. Association members provide industrial training places for students of the two biomedical engineering programmes in Hong Kong.

Outlook of Biomedical Engineering Education and Training in Hong Kong

It is certain that, as with the biomedical industry, biomedical engineering education and training is booming in Hong Kong and the region. Hong Kong has eight University Grants Council (UGC) supported tertiary institutions. At the tertiary education level, universities which currently do not have Bachelor degree level biomedical engineering programmes will probably want to provide these programmes in the near future. This is perhaps especially true for CUHK which has over the years established a good research record in biomedical engineering (leaning to the electrical and electronic side) and also for HKUST which has already had a postgraduate biomedical engineering programme. One key point for Bachelor degree level biomedical engineering programmes in Hong Kong (both existing and new programmes) is how to create their distinctive features in alignment with respective university’s missions and to attractive best possible students to their programmes. The two existing Bachelor degree level biomedical engineering programmes offered by PolyU and HKU, respectively, have started to build up their own identities. But as people who have been deeply involved in biomedical engineering education know, the process is neither short nor easy to go through.

PolyU and HKUST have established MSc in biomedical engineering programmes. It is not difficult to envisage that HKU will wish to offer the MSc level education and training in biomedical engineering. CUHK may well consider offering an MSc level programme. However, with Hong Kong UGC’s self-funding policy for all MSc programmes (in science, engineering, arts, etc.), the universities may face financial difficulties in running MSc in Biomedical Engineering programmes, whether these programmes are considered good or not.

Professional training and continuing education in biomedical engineering in Hong Kong appear to be in good arrangement due to efforts made by the professional society and trade association. With the impetus of Government’s intention and indication of strongly supporting the local medical devices and diagnostics industry, it can be envisaged that the professional society and the trade association will give stronger support to universities for biomedical engineering education and training in Hong Kong. There hence appears another key and delicate issue of how to perfect the mechanism of strongly supporting each other among university education, the profession and industry.

The future of biomedical engineering education and training in Hong Kong looks bright, although there could be obstacles, big or small, along its course of development.

Special Note

The authors of this paper are corporate members of the Hong Kong Institution of Engineers and are currently serving in the Biomedical Division Committee of HKIE. However, views and opinions expressed in this paper do not represent those of either the Biomedical Division or the Hong Kong Institution of Engineers. They do not represent views and policies of respective institutions either where the authors are working. Dr. D. H. K. Chow is thanked for providing an update of the BME programme at PolyU. The authors apologise to those colleagues in Hong Kong whose work in biomedical engineering education and training has inadvertently not been covered in this paper.

Useful Web Sites

1. [http://www.polyu.edu.hk/%7EEREc/](http://www.polyu.edu.hk/%7EEREc/)
3. [http://www.rs.polyu.edu.hk/](http://www.rs.polyu.edu.hk/)
9. [http://www hkpc.org/hkpc/home/](http://www hkpc.org/hkpc/home/)