Work in Progress: An Engineering in Medicine Programme - Opening Engineering Students' Mind Through a Living Laboratory Education

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Abstract

The successful adoption of technology in medicine depends on an interdisciplinary cooperation among specialists in the various medical, rehabilitation and engineering fields. Often, engineers and doctors are not trained to work with each other and may not know how to fully leverage the expertise on each side. An objective of the Engineering in Medicine Programme is to have engineering students learn from and work closely with doctors and members of the engineering faculty to conceptualise, design, test and develop solutions for rehabilitation medicine. Designed specially to bridge engineering and medicine, the programme introduces engineering students to the realities and challenges they will face when developing practical solutions for rehabilitation engineering.

Introduction

Bioengineers provide the bridge between medicine and engineering. The bioengineering education should ensure the students are able to acquire the vital engineering knowledge in the field of biomedical engineering, and also to gain an appreciation of the art and science of medicine. Besides the occasional visits to hospitals and interaction with medical professionals, extended period of immersion in the hospital and first-hand interaction with the patients will be very beneficial. An Engineering in Medicine (EIM) programme in Rehabilitation Engineering has been co-developed by the Faculty of Engineering (FoE) at the National University of Singapore (NUS), together with the Department of Rehabilitation Medicine in the Singapore General Hospital (SGH). The country's first undergraduate EIM programme co-taught by engineers and medical doctors, it offers the engineering students an unique learning experience in a living laboratory setting. The classes are conducted in the hospital, in the rehabilitation gym and right at the bedside. The students are taught by the medical doctors and physiotherapists on the basics of anatomy and rehabilitation medicine, the various forms of rehabilitation (restorative and compensatory), and the equipment used in rehabilitation. The students are required to come close to the patients and interview the patients to understand more of their medical conditions, their living life style and their basic needs after discharging from the hospital. This level of close contact with the patients will allow the students to understand the needs of the patients better, and trigger their mind to come up with engineering solutions through the user-centric design approach. This is also a valuable experience where engineering students would not be able to acquire normally.

This EIM programme is incorporated into the Design-Centric Programme[1] (DCP) of the Faculty of Engineering in NUS. DCP is a flexible and self-exploratory alternative learning pathway, where undergraduate engineering students will work on multi-year, multi-disciplinary projects which address complex and coupled problems. The students will work in groups (comprising of students from different engineering disciplines) to identify the medical needs in rehabilitation, and to conceptualize and develop engineering solutions, and eventually to deliver integrated solutions in the hospital. The students will spend 3 years working on the projects, and be guided

by a team of mentors (from academic and industry/hospitals) with diverse background. The first intake, which began in August 2012, has enrolled 15 engineering students (7 bioengineering, 5 mechanical engineering and 3 electrical engineering). The enrollment number is kept small so as to ensure quality supervision received by the students. And the multi-disciplinary group will encourage cross-disciplinary exchange between the students thereby enriching the students' learning experience.

Structure of the Programme

The university's engineering curriculum is divided into 8 semesters (4 years), and the structure of the EIM programme is shown in Fig. 1. While the students are enrolled in the programme, they continue to take the core modules and technical electives in their home departments (bioengineering, mechanical engineering and electrical engineering). The students enter the DCP-EIM programme at semester 3 (year 2) and work on the project for the next 3 years. Through an interview session, the students are selected based on their aptitude and skill-sets relevant to rehabilitation engineering. In semester 3, the students are to undergo a hospital immersion module (taken as an "Unrestricted Elective Module") where the basics and fundamentals of rehabilitation medicine are taught. The classes are conducted in the hospital, in the rehabilitation gym and right at the bedside by medical doctors and physiotherapists. The topics include Neuroanatomy and Stroke, Parkinson's Disease, Traumatic Brain and Spinal Cord Injuries, Physiotherapy and Occupational Therapy, Speech and Music Therapy, Rehabilitation Equipment, and Nursing in Rehabilitation and Medicine. Ethnography (observational skills) and effective interviewing techniques are also taught before the students begin their immersion in the hospital. Equipped with the essential skills, the students enter the hospital with an open but mindful mentality to observe, at the same time be sensitive and able to direct relevant questions to the patients. During the immersion period, the students will observe first-hand how clinicians and therapists work with patients, and to identify the medical needs in rehabilitation, and to brainstorm in groups for potential solutions. At the end of the semester, the students will build low resolution prototypes (from papers, cardboards, metal sheets, plasticine etc) to demonstrate the functionality of the ideas conceptualised.

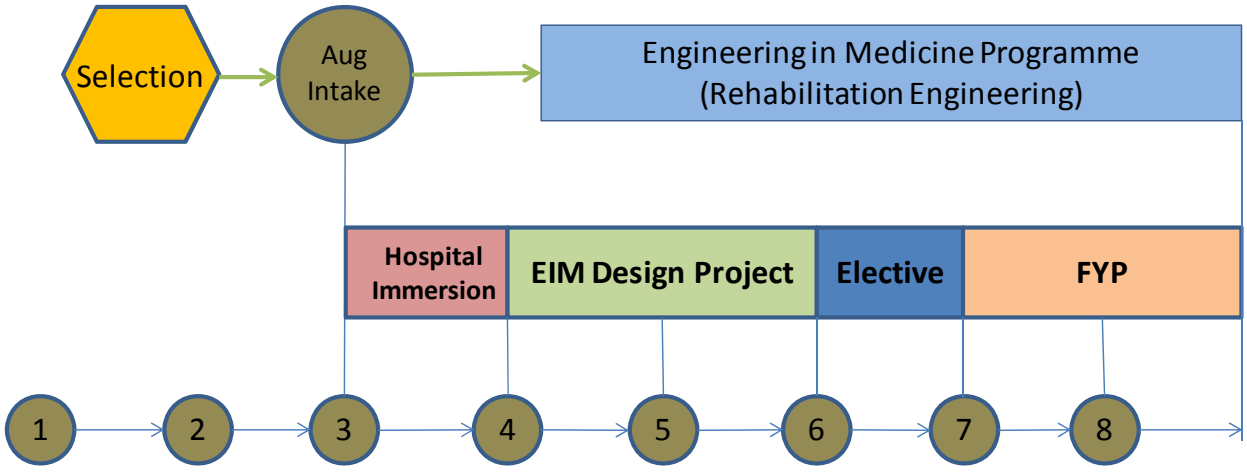

Figure 1: Timeline of the DCP-EIM Programme.

Starting from semester 4, the medical professionals in the hospital (either a doctor, physiotherapist or senior nurse) will be appointed as sponsors for the students' design projects. The hospital sponsors will jointly supervise the projects with faculty members in the Engineering Faculty from semester 4 to the end of semester 8. With the multi-disciplinary nature of the project, each project group will consist of students from different engineering backgrounds. The role of the sponsor is to ensure the relevance of the project to their medical practice, providing advice and enhancing the students' learning in the medical field, and to facilitate essential access to hospital facilities (and patients) and useful contacts in relation to the project. The engineering faculty members will provide technical expertise and guidance. The students will apply the engineering principles from their respective backgrounds to the project, and will work closely with the sponsor and their engineering supervisors to develop engineering solutions, and eventually to integrate the solutions in the rehabilitation process.

In semesters 4 & 5, the students will take the "EIM Design Project" module instead of the design modules in the home departments (i.e. the students will not work on the design projects offered by the department faculty members). Engineering design methods will be taught to the students in classes and the students are to work in groups of 3-4 members to design and fabricate a functional prototype at the end of the semester. The prototype can be a device for restorative, compensatory or diagnostic purpose. Throughout the 2 semesters, the students will continue to visit the hospital and the rehabilitation gym, and talk to the patients. This will allow them to understand the specific needs of the doctors, therapists and patients so that they can improve on their design. The deliverables of this module are design project reports, prototypes and logbook documenting the design process of the project. In semester 7, the students will be required to take an elective module that enhances their understanding and knowledge of the project.

In semesters 7 & 8, the students will continue the DCP-EIM project as their Final Year Project (FYP). At this stage, the direction of the project can take various forms. If the prototype requires further technical development, a more advanced device will be designed, built and tested. A prospective clinical study could also be planned and carried out to study the effect of the intervention of the new device on routine rehabilitation process. The students can explore the possibility of integrating the device in the hospital system or a rehabilitation process to assess its usefulness and functionality. The progress of the project is very much students self-directed at this stage, and the deliverables of this module are individual project reports, prototypes and logbook.

One of the projects undertaken by a group of 4 students (2 bioengineering, 1 mechanical and 1 electrical engineering) is the development of a monitoring and assistive device for stroke patients to quantitatively and objectively assess patients' motor ability recovery progress, with an interest of building a database for the diagnosis of the condition of new stroke patients. The students are currently in semester 4, and are in the progress of building the functional prototype.

Anticipated Outcome and Assessment

An anticipated outcome of the EIM programme is the development of useful engineering solutions to help patients and their care-givers in the rehabilitation process and beyond. The engineering solutions are to be co-developed by the students and medical professionals, and be

integrated in the rehabilitation process and used by the patients. The success of the programme is not solely measured by the functionality of the solution developed. This programme also aims to build up the problem formulation skills of the engineering students through the user-centric design approach. The students are assessed not only by the eventual outcome and functionality of the solutions, they are continuously challenged to observe and understand the immediate needs of the users. Before any solution is proposed, the students must know how to identify and understand the problem well. The students are immersed in the hospital to observe and interact with the patients, care-givers and medical professionals. The students will also learn the vocabulary and roles of the different specialists, the challenges and current treatment methods, and functions of state-of-the-art medical equipment with a focus on rehabilitation. Through identifying the problems on their own, it is expected that the students will gain ownership of their projects and have greater motivation to strive for better solutions for the users.

The EIM programme is a structured curriculum taught by specialists from both the medical and engineering fields, and it includes a clinical component where engineering students learn how to work with patients under the supervision of the healthcare professionals. The programme offers the engineering students a unique learning experience in a living laboratory setting. It is hopefully that with the success of the EIM programme in Rehabilitation Medicine, it can be expanded to other medical fields such as Anaesthesia, Nephrology, Orthopaedics and Paediatrics.

Reference

1. JH Choo, Design Thinking Engineers – Walking the Design-Centric Path at NUS, Innovation 11 (1), 2012.