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Promoting Interdisciplinary Project-Based Learning to Build the Skill Sets for Research and Development of Medical Devices in Academia

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Abstract - The worldwide need for rapid expansion and diversification of medical devices and the corresponding requirements in industry pose arduous challenges for educators to train undergraduate biomedical engineering (BME) students. Preparing BME students for working in the research and development (R&D) in medical device industry is not easily accomplished by adopting traditional pedagogical methods. Even with the inclusion of the design and development elements in capstone projects, medical device industry may be still experience a gap in fulfilling their needs in R&D. This paper proposes a new model based on interdisciplinary project-based learning (IDPBL) to address the requirements of building the necessary skill sets in academia for carrying out R&D in medical device industry. The proposed model incorporates IDPBL modules distributed in a stepwise fashion through the four years of a typical BME program. The proposed model involves buy-in and collaboration from faculty as well as students. The implementation of the proposed design in an undergraduate BME program is still in process. However, a variant of the proposed IDPBL method has been attempted at a limited scale at the postgraduate level and has shown some success. Extrapolating the previous results, the adoption of the IDPBL to BME training seems to suggest promising outcomes. Despite numerous implementation challenges, with continued efforts, the proposed IDPBL will be valuable n academia for skill sets building for medical device R&D.

K*eywords* – interdisciplinary project based learning, biomedical engineering collaboration, medical device research and development.

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INTRODUCTION

Rapid developments of technology in engineering are creating opportunities for technology-led innovations in medical devices. The fast paced growth in multiple engineering disciplines as well as life science applications poses a unique challenge for biomedical engineers [1]. Though growth and development are both positive outcomes for the BME field, a problem also arises: how can educators effectively train BME students to enter an area of work in R&D that is constantly posing increasing demands? Training biomedical engineers with the skill sets they need for R&D, while keeping pace with technological growth and innovation, presents an arduous challenge for educators [2].

Medical device industry personnel notice a gap in the skill sets particularly in the R & D domain. Employers have difficulty finding biomedical engineers with experience relevant to research in industry, and in particular, the engineers recruited from university lacked "job readiness," [3]. Skills such as technical competence, critical thinking, problem solving, interpersonal communications, and technical writing have been listed by industry employers among the most common deficiencies in BME hires in recent years [4].

The basic training of engineers to work in R&D in industry takes places in an academic setting. It is indeed difficult to include courses incorporating training modules in order to embed skill sets for R&D in students at the undergraduate level. Even the skills acquired through a multitude of courses from different disciplines in an undergraduate curriculum may not take the students to a R&D job ready state.

It is generally felt that engineering curricula are too focused on technical courses and engineering science without providing a platform for integration and application to industrial R&D [5]. Some curricula are comprised of design components and courses, whereas others still follow a more traditional approach with the design course in the final year. Though both approaches cover important aspects of basic engineering, they lack the interdisciplinary, interpersonal, and other training that is necessary for success in medical device development. It is clear that there is a need for developing a feasible solution to address the issue of building "the right" skill sets for R&D in medical industry.

The objective of the present study is to propose a new model for an undergraduate BME curriculum in order to provide students with the skill sets to construct innovative solutions in R&D of medical devices that will meet the exigent needs of the real world.

BACKGROUND

To build the skill sets required for medical device R&D in academia, a new model is developed. IDPBL is a powerful technique that both challenges and engages students of multiple disciplines. In this model, IDPBL is aimed at enhancing the R & D capabilities in undergraduate students for developing new medical devices. IDPBL-based approach triggers creative solutions to challenging medical problems and serves as a vital resource for developing new medical devices using state-of-the-art technologies from multiple disciplines. BME specifically involves fusing tools and techniques to solve problems in medicine and biology, which requires the flexibility and true interdisciplinary approach that IDPBL provides [6]. Results have been reported on problem based education in medicine. These studies have concluded that, "the process requires time, energy, planning and autonomy. Data demonstrate that stress related variables have become a central element of students' engagement and persistence," [7]. It appears that IDPBL has not been extensively used in undergraduate BME training in colleges and universities.

DESIGN

Keeping R&D of medical devices the main goal, the curriculum to embedding IDPBL must include a greater emphasis on R&D aspects in a distributed fashion. Some undergraduate programs have engaged a research expedience program, usually as a summer course [8]. Most schools following a PBL system require a form of a capstone project from every student for graduation. Normally these projects take up two semesters and students will work in blended teams. A new model is proposed in this paper, in which the selected features of research expedience experience would be implemented in the regular terms with the inclusion of IDPBL.

The proposed model implements a stepwise increase in the IDPBL distribution percentage, spreading modules over the four years of the undergraduate program. The increasing distribution is depicted in Fig. 1, showing the increase from ten percent of courses being IDPBL based in the first year, to fifteen percent the next year, twenty-five percent in the year following, and in the fourth and final year, to thirty-five percent. The period of the capstone project would be modified from a typical two semesters to an extended four semesters. The requirements would be fulfilled in two stages, where the student typically takes on two independent, yet interdisciplinary, projects, working with separate teams.

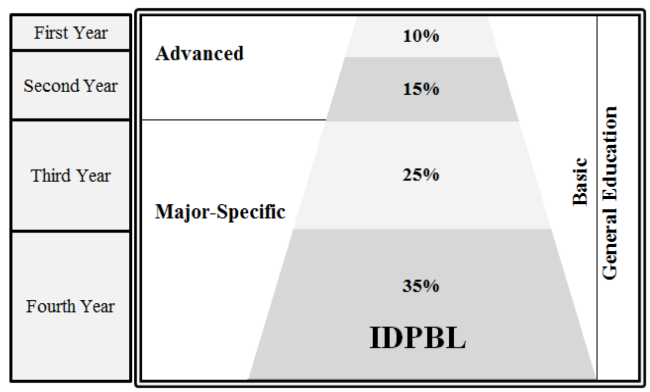

Fig. 1. Proposed Model Showing Distribution of IDPBL modules in a four-year curriculum

It is obvious that inclusion of the IDPBL modules and/or courses will require reduction and/or elimination of some existing courses in the curriculum. This constraint, coupled with forming interdisciplinary groups and synchronizing schedules, makes embedding IDPBL in the existing curricula a real challenge. With a diligent design, the curriculum can be progressively changed for suitably sandwiching IDPBL.

RESULTS

A variant of IDPBL approaches were attempted a few institutions mostly at graduate levels. Many of the projects can be considered to have achieved some success. Student learning outcomes have been positive, along the lines of the anticipated goals. The projects at the graduate level were associated with the selected research work. Some of the projects were also directed at the undergraduate level.

At graduate level collaboration with the University of New Brunswick, research was aimed at digital image processing and quantitative characterization of endoscopic images. This development involved the collaboration of BME graduate students, computer scientists specializing in image processing, a gastrointestinal surgeon and the author, a BME professor.

The Universite de Technologie de Compiegne in France participated in graduate level IDPBL in the development of system level documentation for intensive care labor and delivery, including physiological data acquisition and networking, and interoperability issues in operating rooms and intelligent interoperable systems for infusion therapy in patient controlled analgesia. This project involved BME graduate students, clinical engineering students, anesthesiologists, biomedical equipment technicians, a clinical engineering professor and the author.

In Singapore, in collaboration with a US start-up company, IDPBL at the undergraduate level has been effective in the research and development of respiratory sounds data acquisition and analysis of pulmonary function abnormalities, as well as home healthcare for high risk patients. This collaboration involved BME undergraduate students, a physiologist, electrical engineers, software specialists and BME professors. .

IDPBL is in the process of being incorporated at an undergraduate level at Wentworth Institute of Technology where BME students will be working on group projects involving students from engineering, technology, design and other disciplines. A few interdisciplinary project involving undergraduates from different majors have started yielding encouraging results.

The author had the opportunity to meet with faculty members from Beihang University in Beijing and Aalborg University in Denmark to discuss about the feasibility of and impact by the introduction of the IDPBL modules into undergraduate programs.

The integration of IDPBL modules may pose severe constraints due to preexisting methods of operations and pedagogies. However, careful infusion of the interdisciplinary components, possibly by collaborating with interested departments from other disciplines as well as other national and international institutions, may lead to successful results.

DISCUSSION

Both students and educators in biomedical engineering can benefit greatly from IDPBL training. Students will be more prepared for the research and development of medical devices. The proposed academic model of IDPBL will build the desired skill set for the research and development of medical devices. This will ultimately yield advantages to all participants, including students, faculty, researchers, administration, health care providers and others. However, it should be noted that the implementation of this model will not escape all challenges.

One foreseeable challenge will be the implementation of collaboration amongst students, faculty members, and entire departments. Students may be accustomed to working in groups with other students of their major, and this advancement could potentially place them outside of their comfort zone. Ultimately this will prepare them for working in the industry R&D.

Most faculty members do not have to collaborate with colleagues from completely different disciplines. However, IDPBL will lead to a more efficient and enjoyable teaching experience, because their students will begin learning from each other, this acquiring essential skill sets for R&D needs.

Synchronizing schedules conveniently for students of different disciplines will be difficult. With a packed undergraduate curriculum in BME, it is a challenge to add new courses or modules and provide intelligent scheduling in the first place.

Resource limitations are undoubtedly problematic in academic settings. Getting laboratory spaces in universities for conducting projects involving students from multiple disciplines with adequate resources, in terms of equipment, technical help, and proper supervision among other related necessities may be difficult.

Departments are asked to educate not only their students, but students of other disciplines; resources that may have been scarce to begin with could become even less accessible. Funding these interdisciplinary projects may have to come from a centralized pool, a shared funding from participating departments, or with industrial sponsorship.

Despite the anticipated challenges, IDPBL will begin to eliminate the weaknesses of the traditional practices, such as the lack of capacity to synthesize, create and design original ideas [8].

R&D work on medical robotic systems can be a very good example to apply IDPBL. This could involve students, faculty, and industry experts from BME, mechanical engineering, computer engineering, electrical engineering, as well as medicine and surgery. Projects such as design of ventricular assist devices, low cost incubators for neonatal infants, peritoneal dialysis, etc. will facilitate knowledge acquisition covering a broad range of disciplines and building the skill sets for medical device R&D.

It is realized that new pedagogical approaches may initially receive mixed reviews and partial success. However, based on the industry requirements for medical device R&D, the introduction of IDPBL seems to be a viable approach. This pedagogy would prepare the students to work in R&D of complex medical devices during times of economic down turn as well as times of economic growth.

CONCLUSION

IDPBL will give students a realistic collaborative experience of sharing skills and information in the research and development, and will provide educators the time and flexibility to promote important cognitive skills, including analysis, synthesis and evaluation. The acquisition of these cognitive skills, along with the collaborative skills and skills specific to the research and development of medical devices, is not an easy feat, but IDPBL can help to secure those essential skill sets. Thus academia can contribute to skill sets building to meet the challenging requirements in R&D of medical devices in industry.

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