Academic Program Models for Undergraduate Biomedical Engineering

Shankar M. Krishnan, Ph.D.
Chair, Dept. of BME & H.C. Lord Chair Professor
WIT, Boston, USA
INTRODUCTION

- Global population is increasing. Life expectancies are going higher.
- Proliferation of medical devices for disease diagnosis and therapy globally.
- Human Resources in BME are absolutely necessary
- Demands for undergrad & graduate BME programs are consistently growing.
- Definite needs for developing appropriate BME educational programs.
- Human Resource requirements in low, medium & high resource settings vary.
- Bigger number of jobs at entry levels. Hence more undergraduate programs.
OBJECTIVES

The objectives of this study are:

- To propose Undergraduate Biomedical Engineering education models in three broad categories

- To make recommendations for development of BME manpower in low resource nations and in some medium resource nations
BACKGROUND

• B.S. degrees in traditional disciplines such as EE, ME, CE, Chem E followed by Electronics, Communications, Environmental, Manufacturing, Materials.

• This study mainly considers US models which are followed in many countries such as Canada, Australia, Singapore, China, Mexico, Malaysia, and others.

• In a typical B.S. (BME) program, students take courses for four years.

• In a given semester of four/five courses, typically 3 credits Lectures, 1cr Lab, and three courses have lab modules.
B.S. (BME) Curriculum Design

- BME programs require basic prep in mathematics, physical and life sciences.
- Students need to get deeper knowledge in two or three disciplines in engineering in order to learn and gain expertise in the multi-disciplinary BME.
- Core courses in BME must be clearly defined.
- Special Elective and Advanced courses in BME may be included based on available faculty expertise, infrastructure, labs, graduate programs and ongoing research projects.
- Program must be dynamic to include emerging areas in BME.
- Capstone courses must be at least two semesters long.
- Inclusion of cooperative experiential learning is highly recommended.
Undergraduate BME Curriculum

- BME Core Courses
- BME Capstone Projects, Design/Special Topics
- BME Elective Courses
- Electrical Engineering & Computer Science
- Mechanical Engineering & Design
- Communications/ Humanities/ Social Sciences
- Math & Physical Sciences
- Biology, Biochemistry, Life Sciences, Anatomy & Physiology
MODEL 1

• Based on BME programs large, research-intensive universities.

• BME curricula divided into basic sciences, mathematics, engineering, computing, core and focus areas in BME, humanities, social sciences and free electives.

• Focus areas depend on the institution’s research expertise and training mission

• Substantial percentage of students go for graduate studies, BME, medicine, MBA,…

• Examples: Johns Hopkins University, Georgia Tech., Duke University, UCSD, B.U.,…
MODEL 2

• Common in teaching intensive colleges.

• Basic areas of sciences, mathematics, engineering, computing, BME core and focus areas, humanities, social sciences and free electives

• Focus areas limited, due to faculty, graduate students, funded research constraints

• In one program, focus areas are medical devices and systems, clinical engineering etc.

• Co-op/Internship required in hospitals/medical companies/other hosts

• Examples: Wentworth Institute of Technology, NJIT, MSOE, Drexel, UConn, RIT
# BMED First Year (Freshman) Courses

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# BMED Fourth Year (Senior) Courses

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Lecture, Labs, Credits Distribution

Distribution of Weekly Lecture Hours, Lab Hours and Semester Credits in B.S. (BME) Program
Credits in BME at WIT

- Math: 12%
- Physics/Chemistry/Biology: 21%
- Biomedical Engineering: 29%
- Engineering: 17%
- Humanities/Social Science: 15%
- English: 6%
% Credit Distribution by Area by Year

- **Senior Year**
  - Engineering: 8%
  - Biomedical Engineering: 19%
  - Humanities / Social Sciences: 6%
- **Freshman Year**
  - Physics/Chemistry/Biology: 9%
  - Math: 6%
  - Engineering: 3%
- **Sophomore Year**
  - Biomedical Engineering: 6%
  - Engineering: 6%
  - Math: 3%
- **Junior Year**
  - Biomedical Engineering: 3%
  - Humanities / Social Sciences: 6%
  - Physics/Chemistry/Biology: 3%
ABET ACCREDITED PROGRAMS

- ABET Database
- Whitaker Foundation Database
- American Society of Engineering Education Database
- US News and World Report Database
- Colleges in US categorized with majors,
MODEL 3

- Students are trained in Biomedical Engineering Technology Associate Degree Programs

- Somewhat equivalent to Polytechnic Programs

- Trained to work as BME Technicians in the initial two years.

- Students are trained to be BME’s or BME Technologists in the subsequent two years.

- For BME Technologists, Examples: IUPUI, DeVry, …, Some post-Associate Degree Programs

- For Transferring to BME Programs, students have take Calculus-based courses, (like Model 2)
Adoption of pseudo-Model 3

- The requirements in low-resource countries are very different
- A modified Model 3 may be adopted in Model 3
- Larger share of Labs and hands-on work are considered
- Project work to meet real needs in local hospitals will be beneficial
- With regional end-user involvement, partial funding may be available
- Top students in the program may move to BME Engineering programs
- These students may transfer to Model 2 or Model 1 universities abroad
- Bulk of the students can handle a large portion of hospital work
Academic Advancement Path for 2-year Associate Degree Holders to pursue Biomedical Engineering Technology Major or Biomedical Engineering prior to graduate studies

- High School Degree
- Associate Degree
- B.S. in BME Tech
  - B.S. in BME or Bioengineering
    - Professional Studies
    - M.S./Ph.D. in BME
  - MBA Mgmt. of Tech.
Results

- Experience with all three models
- Model 1: University of Rhode Island, University of Miami, NTU in Singapore
- Model 2: Wentworth Institute of Technology
- Model 3: Southern Illinois University, Ngee Ann Polytechnic (Singapore), Community College in Boston,..
- Familiar with a few programs in India, France,…
- Models are related to research intensive factors, doctoral and post-doctoral programs, available, research grants
Discussion

- Graduation rates are higher in Model 1 followed by Model 2
- Higher studies: large percentage in Model 1
- Model 2 and Model 3 graduates fill most entry level BME positions
- Model 3 students tend to take more than 4 years, typically 6 years to complete
- Also common in many schools is an Engineering major (such as Electrical Engineering or Mechanical Engineering) with a concentration in BME
- Concentration may require students to take more courses (more credit hours)
- Experience with a Five year Electro-Mechanical Engineering program
- Some universities have a five year B.S.+M.S. Program (similar to European)
Academic Ladder

B.S. (BME) WIT

JOBS! JOBS! JOBS!

Graduate Studies

Entrepreneur/ Business

M.S./Ph.D BME

M.S./Ph.D Engineering

M.D. D.V.M. D.D.M.

J.D.

M.B.A.
CHALLENGES

• Manpower

• Facility requirements

• Funding for program development and sustainability

• Time constraints

• Attracting and retaining good students

• Recruiting dedicated faculty
DISCUSSION

- Institutional, Regional and National requirements need to be met
- Market demand is an important factor for undergraduate and graduate level
- Due to globalization, jobs are available worldwide
- Available training with NGOs
- Training within hospitals affects the program model
- Accreditation requirements need to be met
Continuing Education

- Human Resource Development starts with undergraduate training
- Rapid Technological Advancements and Applications to the Medical Field
- BME graduates require continuing education to keep updated
- Irrespective of Degree level, life-long learning, may be fun for many…
- Companies and Hospitals have budgets for training BME staff
- Many organizations have funds for staff career growth, pay for grad studies
- Some high school students start taking courses for college credit
- Human Resource Development covers a broad spectrum
CONCLUSION

• Three models for BME programs are described based on large universities, undergraduate colleges and community colleges.

• Models 2 and 3 can be successfully implemented in nations with low and medium resources with appropriate guidance and support from international organizations.

• Vision (Long term) is to Reach Universal BME Human Resource Building with multiple models in varying resource settings !!!
• Thank you for your attention

• smkrishnan@gmail.com