Implementation of A 5-Year, Thesis-Based B.S./M.S. Degree Program in Biomedical Engineering

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Abstract

The graduate Department of Biomedical Engineering at the University of North Carolina offers a 5-Year Biomedical Engineering Master's Degree program in three undergraduate tracks in Applied Science: Biomedical Engineering, Computer Engineering, and Material Sciences. Each of these fields of study have counterparts in our graduate program in biomedical engineering that includes concentrations in instrumentation, biomaterials, biological systems, genomics, sensors, and tissue engineering. This 5-Year Master's program has been very popular with undergraduates seeking advanced study in biomedical engineering and, for some students, it has been a motivating factor in achieving academic success. Approximately 20% of the students admitted for graduate studies in the Department of Biomedical Engineering enter using this mechanism. These students have proven to perform on par with the competitively admitted BME graduate students and finish within the expected time frame. Additionally, many of these 5-Year Master's students, who enter with limited educational aspirations, continue for the Ph.D. On the undergraduate side, an unanticipated outcome is that the prospect of a seamless 5-Year Master's Degree program is a compelling feature that is attractive to the best students attending UNC-CH for their undergraduate education.

Introduction

An efficient process for attaining a Master's degree following a successful four-year undergraduate effort in a challenging engineering curriculum is desirable for the retention of the best students for graduate level education. Successful programs must be brief and rewarding for the student, yet not compromise the quality of the advanced degree sought. At UNC-CH, we have found that this can be achieved when the two degrees are coordinated such that the graduate level studies continue seamlessly in both academics and research. One challenge in accomplishing that goal is peculiar to UNC-CH, i.e., separate departments, Schools, and Associate Chancellors are part of the overall administrative structure of the program. The undergraduate programs are in the Curriculum of Material and Applied Sciences in the School of Arts and Sciences, while the graduate Department of Biomedical Engineering is in the School of Medicine.

At a time when enrollment in undergraduate engineering is generally flat, biomedical engineering is enjoying double digit growth [1]. This may be in part due to the interdisciplinary nature of the field, the direct connection in this field to helping people, and the dramatically expanding scope of the field. It is incumbent for educators in this discipline to be innovative in the approach to delivering the very broad fundamentals needed while not diluting the aspects of

biomedical engineering which make it so attractive to students. A streamlined MS degree, with emphasis on practical applications in the field may help in achieving this goal.

Admission

Students planning to enter the 5-Year Master's program from any of the three participating undergraduate curricula are required to take the fundamental courses in biology, human anatomy and physiology, as well as a graduate level course in statistical inference during their undergraduate preparation. They are expected to obtain a BME faculty mentor and initiate a research project by their senior year, and that research will lead to their Master's thesis research. This can be accomplished both via optional (for credit) undergraduate research as well as careful planning of their Senior Design Projects.

Students wishing to complete a 5-Year Master's program must attain at least a 3.0 GPA in their major undergraduate course work (courses in Applied Sciences, Biology, Biomedical Engineering, Chemistry, Mathematics, and Physics). While the GRE is not considered in the admission process for these students into the department, they must meet the general admission standards of the Graduate School, which includes a minimum score of 50th percentile on the GRE in both quantitative and verbal portions. Careful, coordinated selection of a Senior Design Project with respect to their proposed Master's thesis has been the most efficient model for completing the Master's Degree in a fifth year of study.

Curriculum

The three undergraduate programs participating in the 5-Year Master's Degree option have been carefully designed to include many of the fundamental introductory graduate level courses offered by the graduate Department of Biomedical Engineering. Therefore, upon entering the graduate program, students in the 5-Year Master's program have already taken much of the first year coursework and are ready to begin specialty courses in their area of interest. An example of the requirements for a 5-year Master's in the Biomedical Engineering track is shown below.

Requirements for advancement to the M.S. Degree program:

• Completion of the B.S. degree requirements for the Curriculum in Applied Sciences - Biomedical Engineering Track.
• Addition or selection as elective courses in that track:
○ BIOL 11 Principles of Biology (3)
○ BIOL 11L Introductory Biology Laboratory (1)
○ BIOL 45 Fundamentals of Human Anatomy and Physiology (3)
○ Students who have the available hours are advised to substitute BIOS 135--Probability and Statistics (4) for STAT 126--Introduction to Probability (Math 146)
• Have earned a QPA of 3.0 or higher in all required courses in Applied Sciences, Biology, Biomedical Engineering, Chemistry, Mathematics, and Physics.
• Meet the minimum Graduate School required scores (50^{th} percentile or above) on the Graduate Record Exam (GRE).
• Select their BME research advisor by the Fall Semester of their Senior year.

Fifth Year Requirement

• *Summer Session (6 credit hours)* All students accepted into the program are required to spend the summer between the senior year and the fifth year in residence. During that summer, students are required to register for Masters thesis research each of two summer sessions.
○ BMME 393, Masters Thesis (2 at 3 hours)
• *Academic Year (24 credit hours required, including the following)*

○ BMME 181/281	Cell and Organ Physiology (8)
-or-	
○ BMME 151/251	Genomic Biology (8)
○ BMME 120	Real-time Computer Applications I (3)
○ BMME 121	Digital Signal Processing (3)
○ 2 electives	Courses selected from BMME 200 and above (6)
○ BMME 311	Research (3-5)
• Pass Qualifying Exam at the M.S. level.	

The "fifth" year includes the summer and academic year after their undergraduate graduation as well as the following summer. Master's candidates are required to earn 31 hours of classroom credit during the academic year, including 6 hours of advanced graduate courses and 8 hours of coursework from one of two Cellular Biology/Physiology course sequences, while completing their research and thesis. In addition, these students must pass a comprehensive qualifying examination and publicly present their thesis to the academic community.

History

The 5-year Master's degree in Biomedical Engineering at was introduced in 1988. This was three years following the creation of the undergraduate Applied Sciences Curriculum at UNC-CH as an interdisciplinary Bachelor of Sciences degree program jointly sponsored by the Departments of Math, Physics, Computer Science, Chemistry (in the School of Applied Sciences) and the Curriculum of Biomedical Engineering (in the School of Medicine). Initially, this option was only available to students in the Computer Science tract of the undergraduate Applied Sciences Curriculum. A similar 5-year Master's Degree was developed for students in the Biomedical Materials tract of the Applied Sciences Curriculum in 1990, at approximately the time that the graduate Curriculum in Biomedical Engineering formally became a department. A major revision of the tracts offered in the undergraduate Applied Sciences Curriculum was completed in 1998, in which the Computer Science tract transitioned into Computer Engineering and Biomedical Engineering. The 5-year Master's degree in Biomedical Engineering was developed for these new tracts at the time they were created.

An average of 2 students per year have taken advantage of this mechanism for entering the graduate BME program in the 14 years of its existence, for an average class size of 14 students per year. They have comprised 14% of the students entering the graduate BME Department. Sixteen have completed their Master's degree and 2 of these continued to complete the Ph.D. at UNC-CH. There are currently 11 Master's degree candidate students in our graduate BME program who have entered through this mechanism. Of the currently enrolled students entering through the 5-Year Master's program, four expect to complete their Ph.D. degrees, and one has been accepted to both M.D. and Ph.D. programs. The total number of students who have either completed or are currently enrolled in the 5-Year Master's degree program over its 14-year existence is 27. These include 8 women and 2 African Americans.

Conclusion

One of the most compelling aspects of this 5-year Master's Degree program for students enrolled or considering the Applied Sciences Curriculum is the assurance that they will be accepted into graduate school with only the requirement that the achieve a 3.0 GPA in their major courses. One concern in the creation of these 5-year Master's degree programs from our faculty was the "take all comers (above 3.0 GPA)" as well as the "non-competitive acceptance"

of students. Over our 14-year experience with this program, we have found that the students entering through this mechanism are on par with the students entering through the competitive admissions process from other institutions. Over the 14-year span of this program, all of the 5-year Master's degree students have completed the degree, or are actively enrolled.

References

[1] IEEE Spectrum, Education (September, 2001), "Teaching from a Clean Slate". http://www.spectrum.ieee.org/careers/careerstemplate.jsp?ArticleId=e090301

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Stephen R. Quint received his BS in Electrical Engineering at Virginia Polytechnic Institute in 1970 and PhD in Biomedical Engineering in 1977. He is currently an Associate Professor in the Departments of Biomedical Engineering and Neurology, and Associate Chair of Applied Sciences at UNC Chapel Hill. His research is concentrated in the application of Signal Processing to problems in medicine.

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