

MEMO

To: The UVM Faculty Senate
From: Curricular Affairs Committee of the Faculty Senate, Laura Almstead, Chair
Date: November 4, 2017
Re: Approval of a proposal for a new Master of Science in Biomedical Engineering submitted by the College of Engineering and Mathematical Sciences in Conjunction with the Graduate College

At its meeting on November 4, 2017, the Curricular Affairs Committee approved the actions recommended in the following memo.

The Curricular Affairs Committee approved a proposal for a new Master of Science in Biomedical Engineering submitted by the College of Engineering and Mathematical Sciences (CEMS). The Program Directors will be Jeff Frolik Ph.D., Department of Electrical and Biomedical Engineering, College of Engineering and Mathematical Sciences and Jason Bates Ph.D., Department of Medicine, Larner College of Medicine. If approved by the Faculty Senate and Board of Trustees, the program will be offered beginning fall 2018.

Program Description and Rationale

The proposed new graduate program will grant a tagged Master of Science (M.S.) degree in Biomedical Engineering (BME), and will be administered through CEMS with strong involvement of the Larner College of Medicine. The general goal of the degree is to develop in students a solid foundation in the quantitative methods of engineering and to provide opportunities to apply them to biomedical problems. Students enrolled in the new M.S. program would be able to pursue one of three options for completion: a research-based thesis option, a project-based option, or a course-work only professional degree option. (See Curriculum section for specific details). Importantly, the proposed M.S. in BME fills a present void between an established Ph.D. program in Bioengineering and a newly introduced B.S. program in Biomedical Engineering. The M.S. program would share and bolster enrollments in the courses that support these existing degree programs.

Justification and Evidence for Demand

Biomedical engineering is a major growth area in the US in part to support an aging population and a demand for improved medical devices and systems. Nationwide, graduation rates at the M.S. level in Biomedical or Biological Engineering have seen a significant growth in recent years (36.9%), comparable or higher than other well-established degree programs indicating there is growing interest for students to receive advance education in this area. Students pursuing the proposed MSBME degree would be able to focus on advanced studies and research related to biomedical engineering.

Graduates of the proposed MSBME degree would be well-positioned to make contributions to growth areas such as computer-assisted surgery, cellular and tissue engineering, rehabilitation, and orthopedic engineering.

The proposed MSBME degree will primarily involve participation from the College of Engineering and Mathematical Sciences (CEMS) and the Larner College of Medicine (LCOM). The proximity of the UVM's engineering programs to the UVM medical school along with existing research collaborations provides the opportunity to develop a unique and high-quality Master of Science degree program. CEMS and LCOM have already collaborated to introduce a Ph.D. in Bioengineering program (2011) and a B.S. in Biomedical Engineering (2016). The proposed new M.S. program will leverage courses already developed and taught by Engineering, Computer Science, and Mathematics and LCOM that support the two existing degree programs. These courses will be taught by engineering faculty who conduct biomedical research, faculty from across LCOM (with backgrounds in quantitative disciplines such as engineering, biophysics and mathematics), and other UVM faculty with expertise related biomechanics, biomaterials, medical instrumentation and imaging, molecular biology, synthetic biology, etc. Faculty teaching these courses would also participate by advising students who choose to pursue the research-oriented thesis option.

Relationship to Existing Programs

As noted previously, the proposed M.S. degree complements an existing Ph.D. program in Biomedical engineering and a newly introduced undergraduate program in Biomedical Engineering. Additionally, the proposed degree leverages strong ties between UVM's Engineering departments and LCOM, and utilizes existing courses that have space for additional enrollment. These courses can be found in all departments in the CEMS and many LCOM departments including Molecular Physiology and Biophysics, Biochemistry, Neurological Sciences, Pathology, and Medicine. Students will also have opportunities to take courses offered by the College of Nursing and Health Sciences (CNHS). It is expected that the MSBME students will primarily take courses from biomedical engineering, electrical engineering (e.g., if they are interested in medical instrumentation), and/or mechanical engineering (e.g., if they are interested in biomechanics).

It should be noted that prior to AY 2012-2013, UVM had a MSBME program that was offered through the School of Engineering and, prior to that, cooperatively through the Department of Mechanical Engineering and the Department of Electrical and Computer Engineering. However, in 2012 this degree was eliminated as part of the conditions of implementing the new Ph.D. in Bioengineering program. A M.S. in Bioengineering degree exists presently. However, it is only an exit degree option for students who do not complete the Ph.D. program, but have met conditions appropriate for the Master's degree. The proposed new MSBME degree differs from the Bioengineering offerings by providing a more distinct focus on engineering methods and their application to address problems related to human health. Unlike the Bioengineering degree program, the proposed MSBME degree requires that the majority of coursework be from the engineering disciplines (CEE, BME, EE, or ME). In contrast to the existing M.S. degrees from Engineering, the proposed program will provide more flexibility for students and will leverage new technical elective courses that are being developed to support the undergraduate biomedical engineering curriculum (BME designation). Furthermore, in support of the undergraduate degree, new faculty with dedicated interests in biomedical engineering

are being hired. This cohort will provide the core faculty to the new M.S. students and the M.S. students will serve to support their research endeavors. Given the success of the Ph.D. in Bioengineering and B.S. in Biomedical Engineering programs, the proposed MSBME degree will be well-positioned to serve as bridge between the current undergraduate and graduate programs. It is also likely to be an attractive option for students completing the B.S. in Biomedical Engineering that are interested in post-baccalaureate studies, but do not want to pursue a doctoral degree. An accelerated option will be available for UVM students (see Curriculum section).

Curriculum

The proposed M.S. in Biomedical Engineering degree will have three options that are described below. All three options require a total of 30 hours of course and/or research credit.

- Coursework only: Thirty credit hours of coursework. At least 18 credit hours will come from CEE, EE, BME, ME, and/or ENGR graduate courses. At least 9 credits will have BME designation, and at least 6 credits will be at the 300-level. A final presentation serves as the comprehensive exam.
- Project-based: Twenty-seven credit hours of coursework plus three credits of project work. At least 18 credit hours will come from CEE, EE, BME, ME, and/or ENGR graduate courses. At least 9 credits will have BME designation, and at least 6 credits will be at the 300-level. Three credit hours of project work conducted with a BME associated faculty is required. A final presentation serves as the comprehensive exam.
- Research-based thesis: Twenty-four credit hours of coursework plus six credits of research. At least 15 credit hours will come from CEE, EE, BME, ME, and/or ENGR graduate courses. At least 6 credits will have BME designation, and at least 6 credits will be at the 300-level. The six credit hours of research must be conducted with a BME associated faculty. A research proposal presentation serves as the comprehensive exam.

Additionally, the degree will have an Accelerated Master's Program (AMP) pathway for current UVM students enrolled in undergraduate programs offered through CEMS. Students choosing the AMP option will take 30 credit-hours in total, six credits of which may overlap with undergraduate credits. Students must apply in their junior year and have a minimum 3.2 GPA. AMP students may pursue any of the three degree options.

Admission Requirements and Process

Students entering the MSBME program must have a baccalaureate degree in an appropriate field of study and demonstrated academic performance as measured by grades and satisfactory scores on the Graduate Record Examination General (Aptitude) section, as well as on the TOEFL or IELTS for non-native English speakers. Students will be selected for admission to this degree program using the same process as currently used for the Ph.D. in Bioengineering. Applicants must submit a full application to the Graduate College that will be reviewed by the Bio/Biomedical Engineering admission committee. Students must meet the GPA, GRE, TOEFL, etc. scores consistent with the expectations of the Graduate College and other Engineering graduate programs. An undergraduate degree in engineering is preferred and coursework in computational science and/or the life sciences is desirable. Specific remedial coursework may be required of those who lack a sufficiently strong background in

certain areas. Students entering the coursework MSBME program under the Accelerated Master's Program (AMP) will have the GRE requirement waived.

Anticipated Enrollment and Impact on Current Programs

The proposers indicate a yearly cohort of between five and ten students. Given the small cohort size and the flexibility in the coursework options, no significant impact is expected on existing programs. The additional M.S. students will help increase enrollments in existing courses that serve the B.S. in Biomedical Engineering and Ph.D. in Bioengineering.

Advising and Assessment Plan

Students pursuing the coursework version MSBME degree will present a plan of study to the Bio/Biomedical Engineering graduate studies committee for approval. These students will be assigned to the Faculty Graduate Program Coordinator as a primary academic advisor to ensure the plan is followed and to facilitate approvals for any changes. Students pursuing a project-based or thesis-based MSBME degree will have a primary research advisor who will approve course selection and advise research. These students will also have project or thesis committees that will participate in advising the student as is the norm for the other Engineering MS degrees. To remain in the program, students must make satisfactory progress on their research (if a thesis-based degree) and must maintain a minimum GPA of 3.0.

The MSBME Curriculum Committee will assess the program annually through feedback from students (course evaluations, additional surveys), enrollment numbers, graduation rates, and level of success in placement post-graduation. In addition, data on journal and conference publications involving students pursuing the thesis-based program will be collected. These data will be compiled and included in an annual report that evaluates both this program and the undergraduate BSBME program. This annual report is already to be developed as part of ABET assessment for UVM's undergraduate engineering programs.

Staffing Plan, Resource Requirements, and Budget

The clerical and logistical issues associated with this degree program will be handled by the staff of the Department of Electrical and Biomedical Engineering. This administrative assistant will coordinate the graduate applications for the proposed MSBME degree and the existing Ph.D. in Bioengineering degree. Support will also be available from the CEMS-wide graduate coordinator. The program will be initially co-coordinated by Dr. Jason Bates, Ph.D. (LCOM), who is presently serving as the graduate coordinator for the Ph.D. Bioengineering degree, and Dr. Jeff Frolik, Interim Chair of the Department of Electrical and Biomedical Engineering. In the future, a new Director may be hired. Faculty who will teach the courses that support this degree will be primarily from the Engineering Departments and LCOM. The proposers expect the MSBME program to attract new students to UVM's existing graduate level courses. Many of the courses that the MSBME students will take are already being offered to support the Ph.D. in Bioengineering program or will be newly offered to support seniors in the BS in Biomedical Engineering program. As noted previously, students pursuing the new M.S. degree will serve only to bolster existing class enrollments and not over burden the offerings.

CEMS recently hired two tenure track faculty in the area of biomedical engineering who will start in fall 2017 and will offer 200-level courses that will support the proposed MSBME degree. These faculty hires will also provide mentorship options for students pursuing either the project-based or thesis-based options. In the future, additional tenure-track hires may be sought, commensurate with the growth of the B.S. and M.S. Biomedical Engineering and Ph.D. Bioengineering programs.

Calculations provided by the Graduate College showed that the proposed MSBME is expected to return positive revenue in its second year and to be sustainable from the point forward.

Evidence of Support

The faculty of the College of Engineering and Mathematical Sciences voted unanimously on January 17, 2017 in support of this proposal. Positive endorsements were attached from the leadership of the CEMS including: Jeff Buzas, Prof. and Chair of the Dept. of Mathematics and Statistics; Mandar Dewoolkar, Assoc. Prof. and interim Chair of the Dept. of Civil and Environmental Engineering; Yves Dubief, Assoc. Prof. and interim Chair of the Dept. of Mechanical Engineering; Margaret Eppstein, Prof. and Chair of the Dept. of Computer Sciences and Jeff Frolik, Prof. interim Chair of the Dept. of Electrical and Biomedical Engineering. The proposal was sent to LCOM faculty in spring 2017, and was approved by the Dean's Office on May 2, 2017. Letters of support for the creation of the MSBME degree were received from Luis Garcia, Dean, College of Engineering and Mathematical Sciences, Frederick Morin, Dean, Larner College of Medicine, Christopher Berger, Dir. Of Graduate and Post-doctoral training, LCOM and Gordon Jensen, Senior Assoc. Dean for Research, LCOM.

Summary

There is strong support for this program in both CEMS and LCOM, and justified need. The newly proposed M.S. in Biomedical Engineering degree fills a present void between the established Ph.D. program in Bioengineering and the recently introduced B.S. program in Biomedical Engineering. Current UVM undergraduates pursuing complementary degrees in CEMS that have interest in the area of biomedical engineering are likely to find the accelerated pathway an attractive option. Students in the newly proposed M.S. degree will also increase enrollments in existing courses that serve the current B.S. and PhD. degrees. Therefore, the proposed MSBME degree leverages existing resources, and could serve as a means for retaining talented UVM undergraduates with an interest in post-baccalaureate work in the field of biomedical engineering that do not want to pursue additional studies. The strong connections and collaborations between CEMS and LCOM position UVM to be able to offer a unique, quality. M.S. in Biomedical Engineering degree.