A Student-Taught Course bringing Research to the Introductory Biomedical Curriculum

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Abstract

In the first year of study for the Undergraduate School of Engineering and Applied Sciences at the University of Virginia (UVa), there are few opportunities for students to explore the field of the biomedical sciences and build research skills. In order to set a precedent for undergraduate teaching and address this shortcoming of the undergraduate BME curriculum, a 1000-level, 1-credit, pass-fail course was designed entitled "Introduction to Regenerative Medicine." Led by a two-student team with one faculty advisor, the focus of the course is to synthesize and contextualize peer-reviewed scientific literature, covering both basic science and clinical applications. Leadership by undergraduate instructors provides a unique perspective on the needs of peers and allows instructors to hone their own research skills. The critical impact of this course is an early introduction to BME and research, and encouragement for younger students to appreciate the value of interdisciplinary interactions.

Keywords

Biomedical, Introductory, Student-taught, Research, Virginia

Introduction

Student Taught Classes

Courses taught by undergraduate students have transformed the scope of an undergraduate education- truly allowing students to take advantage and control of their education. Programs like this are offered at only a handful of Universities around the nation—including Rice University and Carnegie Mellon University. At the University of Virginia (UVa), there are a variety of student taught programs, divided solely based on academic school or residential/scholar program.

In the School of Engineering & Applied Science (SEAS), the UVa Engineering Student Council organizes the Student Taught Classes (STC) program each semester, complete with a required application, potential syllabus, advisor, and sample lecture evaluation. The program aims to allow students to showcase the knowledge and expertise they have gathered during their time at UVa. Students who teach STCs have backgrounds that range from high school experiences, internships, research positions, to organizations outside the classroom. STCs are traditionally 1-credit, pass/fail courses taught by undergraduate engineering students, with course sizes averaging 20 participants per class.

Undergraduate Biomedical Engineering Curriculum

Biomedical Engineering (BME) is The University of Virginia's highest ranked science or engineering program, accredited since 2006 and featuring 21 faculty and 300 undergraduate students[1]. However as shown in Figure 1, the undergraduate BME curriculum does not begin until the student's second year at the University[2]. Students therefore lack early opportunities to experience topics within the field of BME to guide their major choice. Moreover, there is not strong development of research skills, particularly high-level literature comprehension, until the latter half of the undergraduate BME curriculum. Our student team aims to address these two needs through design and implementation of an introductory BME course at UVa.

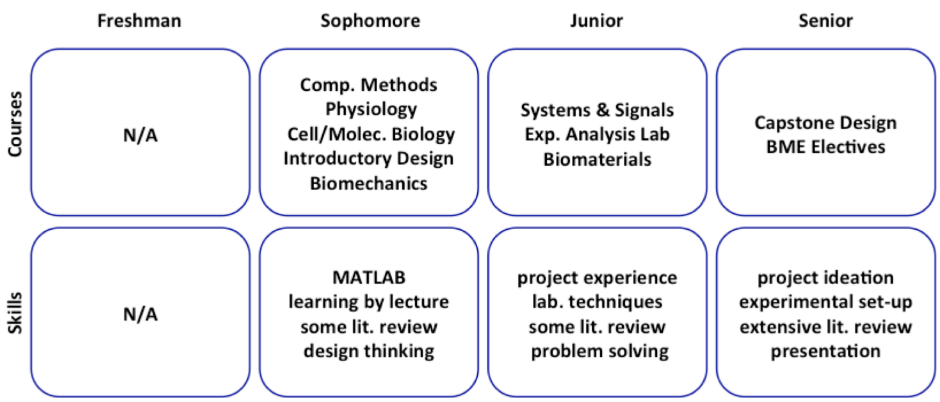

Figure 1. Current required BME curriculum at the University of Virginia

Developed Course: Research in Regenerative Medicine I/II

To provide an introductory BME course encouraging early involvement in research, we designed a 1000-level, 1-credit, pass-fail course entitled "Research in Regenerative Medicine." This course provides a direct link between the concurrent need to learn and desire to advise student participants. The field of regenerative medicine was chosen as a trendy but important BME topic not offered as an upperclassman elective, that could act as the tool by which to teach the course's practical skills[3]. The course is open to students of all years and majors. This diverse demographic encourages interdisciplinary discussion and spread of research skills and a working knowledge of BME topics throughout the University.

Methodology

Course Objectives and Structure

In the design of the course, the objective was to introduce students to biomedical engineering, research, and experiential learning. The course was implemented to (1) give students the skills to be able to analyze and break down articles of literature from a variety of sources, including both review papers and primary journal articles, (2) give students a glimpse at the skills necessary to pursue undergraduate research, as well as provide opportunities to get a head start in these areas, and (3) master and understand the basic concepts of regenerative medicine.

A 6-15 page recent scientific primary or review article is assigned as reading for each class. At the beginning of each class, a short 5-minute quiz is administered relating to the current topic. These questions are based on discussion material from the previous class, as well as the main concepts in the assigned literature. Each quiz consists of multiple-choice and free-response questions. Students are allowed to retake any of these quizzes an unlimited number of times until the following class period.

The remainder of each class is split up into (1) discussing the scientific background behind topics covered in each article, (2) discussing the purpose and methods of the article, (3) explanations concluded from the study, and (4) future implications of this work and regenerative therapies. In some class periods, a clinical case study is presented for students to work through as a group. Throughout the semester, three class periods are dedicated to guest lecturers from related fields.

Finally, the course is graded in a pass/fail manner with the following scoring breakdown: class participation and attendance, 50%; weekly quizzes, 30%; research assignment, 5%; final project, 15%.

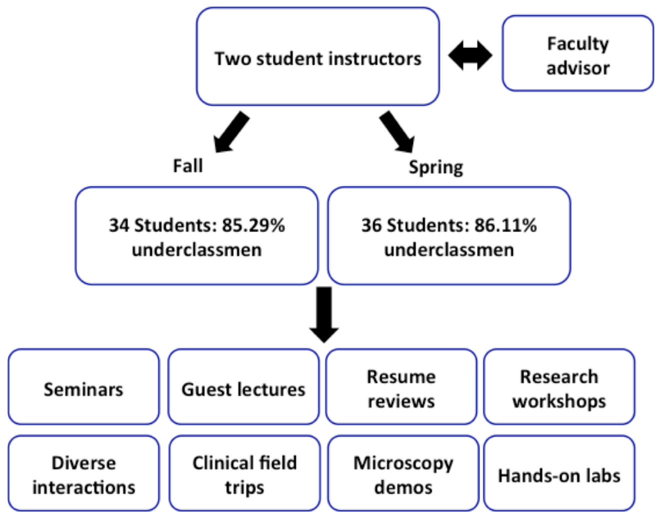

Figure 2. Course structure for the 2015-2016 academic year

Workshops and Experiential Learning

Throughout the course, we also introduce students to a variety of areas, including research skills, which include technical resume composition, interview skills, and an introduction to biomedical science labs at the University. In addition, students have had the opportunity to explore 3D bioprinting, animal models, a Good Manufacturing Practice (GMP) facility, cell culturing labs, and much more, all in the context and focus of regenerative medicine.

Preliminary Conclusions and Discussions

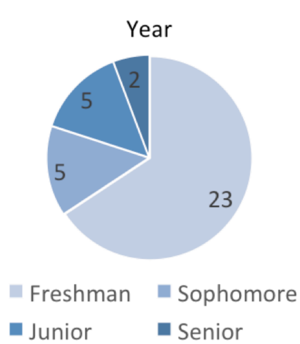

Figure 3. Year distribution of students per semester.

The majority of students, as indicated by demographic pooling in Figure 3, are first year, pre-BME. Prior to taking our course, over 90% of the class identified with being only "somewhat," "not very," or "not at all" familiar with reading primary scientific literature and discussing high-level scientific topics. Introducing a literature-based course into the BME setting has given students in their first two years of study the opportunity to learn essential research techniques, commonly introduced later in an undergraduate BME degree program. Material in the course therefore not only pre-exposes students to the skills necessary to excel in their later required courses, but also emphasizes the synergy between different BME disciplines, providing students with both the technical skills and framework to get involved in a lab early.

References

1. University of Virginia Department of Biomedical Engineering. (2016a). Why UVa Biomedical Engineering? Retrieved from the University of Virginia Department of Biomedical Engineering website: http://bme.virginia.edu/undergraduate/index.html

2. University of Virginia Department of Biomedical Engineering. (2016b, November). BME Student Guide [Handbook]. Retrieved from http://bme.virginia.edu/downloads/2017_BMEStudentGuide.pdf

3. Zydney, A.L., Bennett, J.S., Shahid, A., Bauer, K.W. "Impact of Undergraduate Research Experience in Engineering." *Journal of Engineering Education*, 2002, 151-157.

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Daniel Naveed Tavakol is a senior undergraduate student at the University of Virginia School of Engineering & Applied Science majoring in Biomedical Engineering. Tavakol is a co-instructor, alongside Cara Broshkevitch, for the "Research in Regenerative Medicine" student-taught course for the past three semesters. Under the direction of Dr. Shayn Peirce-Cottler, he also studies tissue and vascular engineering in the context of diabetic changes to pericyte-endothelial cell interactions during angiogenesis.

Cara Broshkevitch

Cara Broshkevitch is a senior undergraduate student at the University of Virginia majoring in Biomedical Engineering with a minor in Engineering Business. Broshkevitch is a co-instructor for the Research in Regenerative Medicine student-taught course. She also conducts research in the University of Virginia Kasson Laboratory using molecular dynamics simulation to construct a mechanistic model of heterogenous cell membrane organization and dynamics to understand influenza viral binding.

William Guilford

Will Guilford is an Associate Professor of Biomedical Engineering at the University of Virginia. He is also the Undergraduate Program Director for Biomedical Engineering, and the Director of Educational Innovation in the School of Engineering. He received his B.S. in Biology and Chemistry from St. Francis College in Ft. Wayne, Indiana and his Ph.D. in Physiology from the University of Arizona. Will did his postdoctoral training in Molecular Biophysics at the University of Vermont under David Warshaw. His research interests include novel assessments of educational efficacy, the molecular basis of cell movement, and the mitigation of infectious diseases.

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Shayn Peirce-Cottler, Ph.D. is Professor of Biomedical Engineering with secondary appointments in the Department of Ophthalmology and Department of Plastic Surgery at the University of Virginia. She received B.S. degrees in Biomedical Engineering and Engineering

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