Board 9: Introducing Bioengineering Approaches through Healthcare Grand Challenges

Dr. Marcia Pool, University of Illinois, Urbana-Champaign

Dr. Marcia Pool is a Teaching Associate Professor and Director of Undergraduate Programs in the Department of Bioengineering at the University of Illinois at Urbana-Champaign (UIUC). She has been active in improving undergraduate education including developing laboratories to enhance experimental design skills and mentoring and guiding student teams through the capstone design and a translational course following capstone design. In her Director role, she works closely with the departmental leadership to manage the undergraduate program including: developing course offering plan, chairing the undergraduate curriculum committee, reviewing and approving course articulations for study abroad, serving as Chief Advisor, and representing the department at the college level meetings. She is also engaged with college recruiting and outreach; she coordinates three summer experiences for high school students visiting Bioengineering and co-coordinates a weeklong Bioengineering summer camp. She has worked with the Cancer Scholars Program since its inception and has supported events for researcHStart. Most recently, she was selected to be an Education Innovation Fellow (EIF) for the Academy for Excellence in Engineering Education (AE3) at UIUC. At the national level, she served as the Executive Director of the biomedical engineering honor society, Alpha Eta Mu Beta (2011-2017) and is an ABET evaluator (2018-present).

Prof. Marina Marjanovic, University of Illinois, Urbana-Champaign

Dr. Marina Marjanovic is a Teaching Associate Professor in the Department of Bioengineering and Associate Director of Center for Optical Molecular Imaging in the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign. She is teaching several undergraduate and graduate courses, and she is active member in the Undergraduate Curriculum Committee. She has been Principal Investigator on several educational grants to technologically enhance biology and physiology courses and develop investigative laboratory exercises. In addition to teaching, she mentors undergraduate and graduate students in cancer research. Since 2014, she has been Co-PI and Program Coordinator for the NSF REU programs: Discoveries in Bioimaging and Frontiers in Biomedical Imaging. Through these programs she is actively recruiting and mentoring nationally exceptional undergraduates from underrepresented groups for summer research and career-building experiences. Every year she is accompanying them to present summer research at the Annual Meeting of the Biomedical Engineering Society (BMES). In the summer, she is organizing and participating in the educational outreach programs such as science summer camps for middle school and high school girls. Before coming to UIUC, she was Associate Professor at the Eastern Illinois University where she mentored female and minority students in science and mathematics. She was Founding Chair and Mentor for the Women in Science and Mathematics (WISM) Initiative and Minority Mentoring in Mathematics and Sciences (M3S).

Work in Progress: Introducing Bioengineering Approaches through Healthcare Grand Challenges

Introduction

As the landscape of health and medicine is changing [1-2], we seek to anticipate these changes and define the professional practice of future bioengineers. Our aim is to educate our bioengineering students to possess *core technical capabilities* that can be applied to *disciplinary problems* with awareness of *societal contexts* with the leadership skills to *produce impactful results*. To begin this training, we are integrating co-curricular, grand-challenge driven tracks into the curriculum for students to address these societal problems in health and medicine.

Our bioengineering program includes five technical track (approach) areas: cell and tissue engineering, therapeutics engineering, biomechanics, computational and systems biology, and imaging and sensing. Each track is composed of fifteen engineering credit hours, and students must select by the end of their sophomore year a track to pursue. Frequently, students are uncertain about their track decision due to limited exposure to the different bioengineering areas at this stage in their education. For example, a student interested in cancer may assume that the cell and tissue engineering track is the most logical fit to study cancer but not realize the potential for cancer-related work in other areas of bioengineering such as imaging and computation. To assist our students in making an informed decision on a technical track while introducing the field of bioengineering to freshman, we modified the delivery of a freshman seminar course Introduction to Bioengineering (BIOE 120). Previously, the course was taught as a seminar in which guest lecturers (faculty) presented their research. We modified the course to (1) inspire students by focusing on grand challenges [3-4], (2) engage students in their learning, (3) engage upper-level students as mentors in the process, and (4) facilitate early development of scientific writing and presentation skills. In the modified course, students work in CATME created teams, guided by mentors and instructors, to investigate how each of the five bioengineering tracks (referred to as "approaches") may be used to investigate the grand challenge.

Course Design and Offerings

The goal of the Introduction to Bioengineering course is to introduce freshman students to the breadth of bioengineering, allowing each student to gain knowledge of the areas in which he/she could become a future leader. Through this course, we aim to provide quality training for students to work cooperatively, think creatively, and synthesize all aspects of biomedical, clinical, behavioral, and health services research. To accomplish these goals, in fall 2016, we reviewed our introductory seminar course. Previously, the course was consistently offered as a one-credit hour seminar in which faculty were invited to speak on their research with the exception of one offering in which students selected a career focus (industry, research, or medical school) and were grouped into career focused sections accordingly. After review of the career-focused style, it was determined to be better suited for more advanced students who understood the bioengineering field, and components of that offering were integrated later in the curriculum. As neither of the previous offerings engaged students in learning the breadth of bioengineering at a novice level, there was an opportunity to reimagine the introductory course. In spring 2017, we offered the healthcare grand challenge focused course for the first time to the

freshman cohort (1-hour lecture /week; 1 credit hour). Following this offering, the course was modified based on lessons learned to better accommodate the structure and needs of the students and faculty and offered again in spring 2018 to the freshman cohort ((1-hour lecture and 1-hour discussion)/week; 1 credit hour). The course is currently being offered in spring 2019, following the format of the spring 2018 course. Both course offering styles focused on healthcare grand challenges with the first offering (67 students) reviewing three challenges and the second and third offering (46 and 73 students, respectively) exploring four challenges. The three healthcare grand challenges common to both offering styles were: global health/infectious diseases, cancer, and neurological diseases; in year two, cardiovascular diseases was added to the course to reflect the Department's increased interest in this area.

The course structure between both offering styles is similar with the 2018 and 2019 format being more compressed due to the addition of the cardiovascular challenge. In the first two weeks, we introduce the course and information literacy. After this, the general structure (Figure 1) for each challenge includes: (1) introduction to the challenge (week 1), (2) guest lecturer – current research (week 2), (3) training in a supporting topic, such as ethics (week 3), and (4) wrap-up discussion of the challenge/delivery of report (week 4). The whole course is coordinated and taught by two teaching faculty (Profs. Marjanovic and Pool). The lecture each week is delivered by faculty. Most guest lecturers are faculty in the Department of Bioengineering, but some are from other departments across the campus. All faculty enthusiastically contribute voluntarily to this course, as their schedules permit.

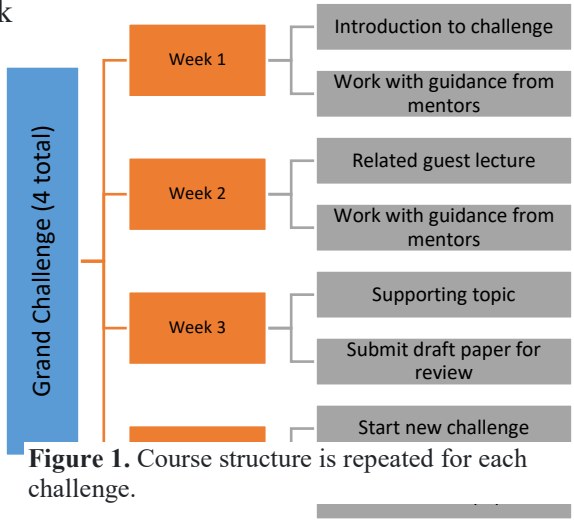

Figure 1. Course structure is repeated for each challenge.

The discussion period each week is dedicated to the teamwork under the guidance of upperclassmen mentors (near peer teachers) [5-7] and faculty instructors. Before the beginning of the semester, upperclassmen are recruited and offered independent study credit (3 credit hours of BIOE X97) for their mentoring. Each mentor works with 2-3 teams guiding them in literature searching, encouraging discussion and participation in the team, reviewing drafts of the reports and providing the feedback to the faculty instructors.

Students work in teams (3-4 per team) to investigate these grand challenges and broaden their understanding of the breadth of the bioengineering field. Each team is required to identify a specific topic within each challenge to investigate (e.g., breast cancer in the cancer challenge; Alzheimer's disease in the neurological diseases, etc.). For each challenge, teams develop a 2-page report documenting with citations how each of the five tracks (approaches) is or could be used to investigate the chosen challenge. Mentors and instructors facilitate team progress in the classroom, but the student's interaction with their mentors is also encouraged outside the classroom. Teams submit a draft of their report in week 3. Prior to submitting the final paper for each challenge (week 4), teams receive feedback on the draft paper from their mentors and/or instructors. The group mentoring activities by upperclassman provide a community structure among the participants to create an environment that supports incoming freshman and their

integration into the department [8-9]. At the end of the semester, students select their favorite challenge, create a conference style poster, and present in a poster session in which the mentors, other students, and faculty serve as the visitors/conference attendees.

Preliminary Results and Discussion

To determine the effect of the course on student's track interest and confidence in literature searching, we administered an end of the semester survey (Table 1) to determine pre-class and post-class differences; an open comment option was also incorporated into the survey. Results from three years of data (2017-2019) will be analyzed to identify the effects of the course redesign on students' perceptions. Preliminary results reveal changes in student track interest (pre-and post-course), especially in some tracks. Response rates were 57% in the first year and 67% in the second year. Surveys in both years also revealed improved confidence in literature searching, 55% in year 1 and 61% in year 2. Student comments revealed they appreciated learning how different tracks (approaches) could be used to tackle a healthcare grand challenge. Comments also indicated that the structure of the course promoted increased literature searching techniques.

Table 1. Questions from the survey distributed at the end of the class.

End of Class Survey Questions
Before completing BIOE 120, rank how you perceived the tracks in order of most interesting (equal to 1) to least interesting (equal to 5).
After completing BIOE 120, rank how you perceive the tracks in order of most interesting (equal to 1) to least interesting (equal to 5).
If your track interest did not change, explain why. If your track interest did change after taking BIOE 120, explain why.
Before completing BIOE 120, how confident in literature searching were you? (very confident to very unconfident).
After completing BIOE 120, how confident in literature searching are you? (very confident to very unconfident).
If your confidence in literature searching changed after taking BIOE 120, explain why.
Please provide any other comments about the class you have.

While the course has indications of benefits to students, it is not without challenges. Restricted course structure experienced in year 1 was alleviated in year 2. However, recruiting mentors is always challenging due to potential time overlap between their required courses and this course. The co-teaching is very effective, yet if a department does not have adequate number of faculty to accommodate co-teaching, the course may be very demanding for one instructor for the large freshman class. While design-focused or other engaging first year courses/experiences are used for retention [9-10], we have not witnessed this as we do not have much attrition after freshman year. Students who do leave usually do so after completing upper level core courses and leave due to poor performance or choose a different engineering career path. However, the course does demonstrate some qualities/experiences that promote positive outcomes and retention [9-11]. Additionally, student's perception of their literature searching used to develop the papers improved. This is consistent with collaborative writing effects [12] and will benefit students as they continue through the program and engage in research experiences.

References:

[1] T. Nilsson and B. Sheppard. “The Changing Face of Medical Device Design,” in McKinsey & Company Pharmaceutical & Medical Products, February 2018, available: https://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/the-changing-face-of-medical-device-design

[2] F. Smith. “How Personalized Medicine is Transforming your Health Care,” in *National Geographic Magazine*, January 2019, available: https://www.nationalgeographic.com/magazine/2019/01/personalized-medicine-transforming-your-health-care/

[3] B. He *et al.*, "Grand Challenges in Interfacing Engineering With Life Sciences and Medicine," *IEEE Transactions on Biomedical Engineering,* vol. 60, no. 3, pp. 589-598, 2013, doi: 10.1109/TBME.2013.2244886.

[4] W. H. Vanderburg and N. Khan, "How Well Is Engineering Education Incorporating Societal Issues?," *Journal of Engineering Education,* vol. 83, no. 4, pp. 357-361, 1994/10/01 1994, doi: 10.1002/j.2168-9830.1994.tb00131.x.

[5] C. Andre, J. Deerin, and L. Leykum, "Students helping students: vertical peer mentoring to enhance the medical school experience," *BMC Research Notes,* journal article vol. 10, no. 1, p. 176, May 02 2017, doi: 10.1186/s13104-017-2498-8.

[6] D. Boud, R. Cohen, and J. Sampson, *Peer Learning in Higher Education: Learning from & with Each Other*. Kogan Page, 2001.

[7] E. Frei, M. Stamm, and B. Buddeberg-Fischer, "Mentoring programs for medical students - a review of the PubMed literature 2000 - 2008," *BMC Medical Education,* vol. 10, no. 1, p. 32, 2010/04/30 2010, doi: 10.1186/1472-6920-10-32.

[8] L. Rubin and C. Hebert, "Model for Active Learning: Collaborative Peer Teaching," *College Teaching,* vol. 46, no. 1, pp. 26-30, 1998/01/01 1998, doi: 10.1080/87567559809596229.

[9] V. Tinto, "Colleges as Communities: Taking Research on Student Persistence Seriously," vol. 21, ed. The Review of Higher Education: Johns Hopkins University Press, 1998, pp. 167-177.

[10] E. Litzler and J. Young, “Understanding the risk of attrition in undergraduate engineering: Results from the project to assess climate in engineering,” *Journal of Engineering Education*, vol. 101, issue 2, pp. 319–345, April 2012.

[11] E. Seymour, et al., “Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study,” *Science Education*, vol. 88, issue 4, 493–534, July 2004.

[12] R. Louth, C. McAllister, and H. A. McAllister, "The Effects of Collaborative Writing Techniques on Freshman Writing and Attitudes," *The Journal of Experimental Education,* vol. 61, no. 3, pp. 215-224, 1993/04/01 1993, doi: 10.1080/00220973.1993.9943862.