An introductory short course in biochemical and biomedical engineering for undergraduate students

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Introduction and Objectives

A pressing need exists to retain undergraduate students in engineering degree programs in the United States. Moreover, the engineering profession continues to struggle with public misperception: the general public believes that, compared with scientists, engineers do less to save lives, are less sensitive to social concerns, and care less about their communities. This suggests that engineering as a profession must do more to communicate what engineers really do, and why engineering is essential for meeting societal needs.

In order to attract undergraduate students to engineering programs, and retain these students in engineering, it is critical to inspire and encourage students to study engineering. With these considerations in mind, I designed an on-campus, four-day short course on bioengineering with the goals of (1) imparting students with knowledge of what biochemical engineers and biomedical engineers do; (2) reinforcing positive perceptions of the bioengineering profession; and (3) increasing student enthusiasm for the study of bioengineering. The course won an award from the 2012 Harvard President's Innovation Fund for Faculty.

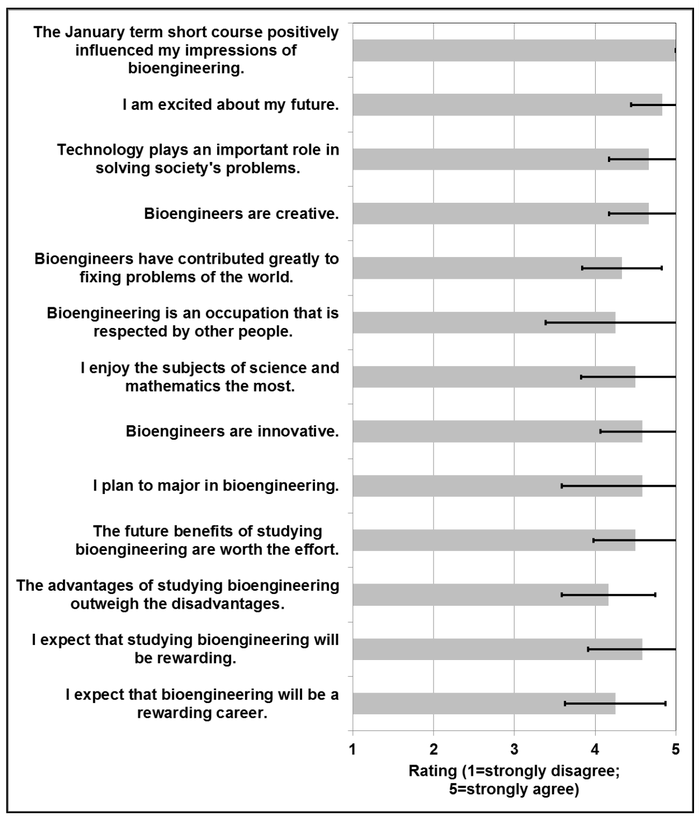
Developmental History of Innovation

- The course was designed as an intimate learning experience for a small class of twelve students, and incorporated both seminars and laboratory activities; it was held during winter break. The course was motivated by the following question: Can students learn core principles of both biochemical engineering and biomedical engineering by exploring a current design problem that incorporates concepts from both disciplines? The selected design problem for the course was the engineering of bio-derived materials for biomedical devices.

- The course was titled, "Sustainable Materials as Biomedical Materials," and allowed students to examine whether materials created through biochemical engineering could be useful for applications in biomedical engineering. Toward the goal of a sustainable bio-economy, research in biochemical engineering is increasingly devoted to the development of renewably sourced materials, such as bio-polymers and bio-composites derived from corn, soy, kenaf, flax, and cellulose. At the same time, innovators in biomedical engineering are seeking novel materials for implantable medical devices which will be optimally compatible with the human body. A natural intersect exists between these two areas of emerging research: naturally sourced polymers may be ideal for the design of new biomedical implants. This interdisciplinary course operated at the intersection of biochemical science, biomedical engineering, molecular biology, and sustainable processing.

Learning Activities, Materials, and Execution

- Students received introductory lectures on biomedical engineering, including implantable biomaterials and drug delivery strategies, as well as biocompatibility testing of biomaterials.
- Students also received introductory lectures on biochemical engineering, including genetic engineering and metabolic engineering.
- Examples of naturally-derived materials for clinical applications were presented to students; one example was the design of polysaccharide-based polymers for wound closure.
- In the hands-on component of the course, students designed and conducted their own experiments in the undergraduate bioengineering laboratories and design laboratories, to explore the biocompatibility of bio-derived materials with clinically relevant cell lines. For instance, one student examined the proliferation of cardiac fibroblasts on naturally-derived agar hydrogels.
- The course attracted a diverse population of students from freshmen through seniors, and was successful in recruiting women and under-represented minorities.



Results

At the conclusion of the course, students completed an anonymous survey which assessed attitudes and motivation to study bioengineering; the survey was adapted from the Pittsburgh Freshmen Engineering Attitudes Survey©. The results, shown in the figure, suggest that the bioengineering short course positively reinforced student perceptions and enthusiasm for studying bioengineering. In particular, all twelve of the students strongly agreed with the statement, "The January term short course positively influenced my impressions of bioengineering." Students were in strong agreement with statements regarding the creativity, innovation, and societal impact of bioengineering. Students also demonstrated a strong excitement regarding future studies of bioengineering, and future careers in bioengineering.

Further, students' anonymous comments revealed the positive impact of the course. One student wrote, "I think this course was really thought-provoking and inspiring…The course made me more confident in my choice of a bioengineering concentration and I leave excited to pursue more work in my field of choice!" Another wrote, "It has shown me the many things one can work on as a bioengineer, and has made me more excited about the subject matter. It has also strengthened my decision of major." Yet another student commented, "Excellent course – so much to think about. I think the field is great." One student commented that the course influenced his perceptions of future career possibilities: "It was definitely helpful in showing me possible career paths, as well as the breadth of opportunities there are in bioengineering." Importantly, a student stated, "I couldn't have thought of anything more that I would have rather done! Really, biochemical and biomedical engineering excite me a lot!" Students clearly came away from the course with a sense of pride in their chosen profession.

Major Issues to Resolve

A more rigorous assessment tool must be developed for the short course.

It is critical to assess the long-term impact of the short course on student performance and student retention in bioengineering degree programs.

It is critical to assess the long-term impact of the short course on students' future choice of careers in engineering.

Discussion and Current Initiatives

This work demonstrates the success of a short course in bioengineering, held during winter break at Harvard. The course incorporated aspects of both biochemical and biomedical engineering. The course generated student excitement for the study of bioengineering, as well as positive student perceptions of the bioengineering profession, particularly the social relevance and impact of bioengineering.

I presented the results of this work at the 2013 IEEE Northeast Bioengineering Conference and the 2013 Annual Meeting of the American Institute of Chemical Engineers.

I have continued the work by voluntarily teaching biopolymer short courses at the 2013 International Biopolymer Workshop in Kenya; the West African Health Technology 2013 Symposium in Nigeria; and the 2013 Workshop on Bio-Based Industry in Mauritius.

In the future, I plan to introduce more rigorous assessment methods, and evaluate whether this type of intensive short course affects student performance and retention in bioengineering degree programs, as well as students' future choice of careers. I also plan to explore whether short courses could be designed for other engineering fields, to attract and retain students in a variety of engineering disciplines. Finally, I would like to investigate whether such a short course could be used to enhance engineering education in developing nations. I believe that a well-designed short course has the potential to attract a diverse population to engineering fields, and impact engineering education and retention not only nationally, but also globally.

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