

AC 2008-505: CAREER AND PROFESSIONAL DEVELOPMENT IN BIOENGINEERING: TRANSLATION OF A CONFERENCE INITIATIVE TO EDUCATION AND TRAINING

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Career and Professional Development in Bioengineering: Translation of a Conference Initiative to Education and Training

Abstract

The Student Activities Committee of the annual conferences of the Institute of Electrical and Electronics Engineers' (IEEE) Engineering in Medicine and Biology Society (EMBS) has developed a unique career and professional development track for undergraduate and graduate students in bioengineering. This initiative debuted at the 2005 IEEE/EMBS conference and has since developed as an integral part of the annual conference. In the 2006 annual conference, approximately 320 student members participated in the student activity sessions—one third of the thousand students who attended the conference. The sessions in this track provide extraordinary opportunities for students to network with leaders and practitioners from both industry and academia. The track has also led to increases in student volunteerism and the creation of innovative sessions. For instance, in 2004 there were no student activities at the annual conference aside from the traditional student paper and design competitions, whereas in 2007 there were about half-a-dozen activities, led by more than 15 student and faculty volunteers. Subject areas in the student activity sessions that are continually featured and well-liked include (1) traditional and non-traditional career opportunities, (2) life strategies for career growth and renewal, (3) leadership, innovation, and entrepreneurial development, and (4) social, ethical, and political stewardship in bioengineering. In this work, we describe our best practices and outcomes in developing these student activity sessions. We also share our experiences on incorporating facets of this initiative into a sample bioengineering educational curriculum and present its relevance to visionary frameworks that include the Accreditation Board for Engineering and Technology's Criterion 3, the National Academies' *Engineer of 2020* and the National Science Foundation's Strategic Plan.

Introduction

There is lively ongoing debate about the essential underpinnings of an engineering education. With growing disparity between technological progress on the one hand, and existing limitations in educational and socioeconomic resources on the other, a varied number of visionary frameworks and strategic plans have been put forth by commissions of the Accreditation Board of Engineering and Technology (ABET)¹, the National Academy of Engineering (NAE)², and the National Science Foundation (NSF)³. A strong, consistent recommendation in these reports is the need for engineering graduates to have professional development, or “soft” skills. The visions of these reports have particular relevance to bioengineering, a discipline whose explosive international growth is generating abundant career development, professional development, and humanitarian development opportunities that require engineers to be poised in terms of both technical and soft skills⁴.

Correspondingly, the Student Activities Committee of the annual conferences of the Institute of Electrical and Electronics Engineers' (IEEE)⁵ Engineering in Medicine and Biology Society (EMBS)⁶ has developed a unique career and professional development track for undergraduate and graduate students in bioengineering. Initiated in 2005 as part of the annual

conference, the student activities committee has since focused on representative themes such as (1) traditional and non-traditional career opportunities, (2) life strategies for career growth and renewal, (3) leadership, innovation, and entrepreneurial development, and (4) social, ethical, and political stewardship in bioengineering.

Implementation

Over the last three years, the EMBS annual conference sessions related to student activities consisted of a wide variety of presentations and crosscutting panel discussions on contemporary topics and issues, which were interspersed throughout the convention. The intent of these sessions was to make the session panelists accessible to students by allowing discussion on professional development topics followed by extensive networking opportunities. The distribution of handouts at the sessions encouraged students to retain the information and take notes. Contact information for the panelists was provided to enable offline interactions.

In addition to the formal sessions, two opportunities were incorporated into the student activities to provide a more personal and intimate introduction to bioengineering. These activities were the Lunch with Leaders and the Mentor programs. The Lunch with Leaders program aimed to connect students with leading practitioners from academia and industry. Over a free lunch, students were given the opportunity to interact with their selected leader on topics concerning research and career development. The Mentor program's objective was to pair students with a Track or Session Chair, thus allowing them to see the inner workings and dynamics of coordinating and preparing for a conference track or session. Students were required to sign up and indicate preferences for specific topic areas for both the Lunch with Leaders and the Mentor program prior to the commencement of the conference.

Topical Areas and Sample Session

The topics for the sessions are typically driven by audience interest and previous session attendance. To aid in the progression of the student activities, the attendees are requested to fill out a questionnaire indicating which sessions they attended, how things could be improved, and new sessions and topical ideas they would like to see at a future conference. Initially, topics were geared more towards graduate research and volunteering within the EMBS; topics offered included "Students: the Movers and Shakers of EMBS" and "Survival 101 for BME Graduate Research." With audience feedback and volunteer creativity, the tracks subsequently evolved to primarily focus on career, professional, and entrepreneurial development in bioengineering. To this end, the 2007 conference featured three sessions named "Innovations and Entrepreneurship in Bioengineering," "Working in Bioengineering: Making an Impact," and "Biomedical Engineering and Society" to reflect this focus. The most successful session was "Innovations and Entrepreneurship in Bioengineering," which was attended by both students and industry professionals. This session focused on such topics as translational academic research, development of a business and marketing plan, and licensing, royalty, and patenting methodologies. The lead panelists comprised both students and professionals and covered material from multiple perspectives, including that of a student, an academic, a person working in private industry, and an entrepreneur. After brief presentations from each panelist, open

forums offered the opportunity for the audience to ask questions and/or give additional comments.

Key Outcomes

Over the last three years, student activities planned at the annual EMBS conferences have enjoyed positive feedback and were well attended. In the 2005 conference held at Shanghai, China, nearly 200 students attended the programs. At the 2006 conference in New York City, we saw an attendance of approximately 320 students, which was one third of the conference's student attendees. The student activities sessions in the 2007 conference at Lyon, France had approximately 180 attendees.

In a 2006 post-conference online survey of EMBS students, of the 27 students who responded that had attended an annual conference, 86% considered the student activities to be excellent or good, while only 14% considered them average. None considered them poor.

The Lunch with Leaders program is consistently popular, recruiting up to 100 students per session. The program appears to benefit from the ability to sign up in advance through the conference registration system. Sessions on professional development, such as panels with representatives from different career paths, are always well attended. A session on varied career opportunities in bioengineering in the 2006 conference attracted slightly in excess of 80 people, while the inaugural session on entrepreneurship in bioengineering in 2007 was attended by nearly 50 people. These numbers reflect a growing interest and commitment of students and young professionals in this area.

Some sessions have yielded low attendance at the conference. For instance, a session in the 2007 conference on how students can get involved in EMBS, such as by forming a club or chapter at their University, was not as widely attended as anticipated. However, the participating individuals were very engaged and some eventually went on to encourage EMBS activities or establish clubs at their respective institutions. Another session on bioengineering and society that debuted in 2007 and sought to explore critical policy and societal linkages of bioengineering, resulted in low attendance and audience participation.

Analysis of Key Outcomes

The success of a session depends on factors such as advertising, student priorities, convenience of attendance and enticements such as free food or give-aways. Promotional marketing is a key aspect of increasing student participation, especially at a large international convention. Methods that have worked well are the distribution of small flyers, email announcements, automated sign-up as part of the conference registration, posters at the conference venue, and word-of-mouth marketing. The titles of sessions should be easily understood, especially when launching new ideas. For example, the session on bioengineering and society may have sounded too vague.

Student priorities govern the interest level in a session topic. In a 2006 survey of 65 EMBS students, nearly 90% ranked professional development as a moderately or extremely

important factor, while only 10% thought it unimportant in bioengineering. Generally, sessions that provided students with career development strategies are popular. Furthermore, for the student activities to be successful, they must be offered during the main conference time schedule at convenient time slots and locations. Offering enticements such as free food or sponsored gifts always attracts students.

Creative Sustainability

The landscape of bioengineering as a profession is dynamic. Professional development activities must therefore be responsive to this environment. At the EMBS conference, key activities are repeated each year, but significant portions evolve and change depending on leadership and prevalent trends. For example, the growing interest of bioengineering students to formally prepare for varied career options, especially in entrepreneurship, spurred the creation of a session on this topic.

The sustainability of student activities at the annual conference depends greatly on institutional memory of the student activities committee, which is supported by the executive office of the EMBS. The organization of sessions depends on the recruitment and volunteerism of high caliber participants from a variety of sectors, including industry, academia and alternative career paths. Volunteers must be able to access or be in a position to create a diverse network of individuals within the related fields of bioengineering. Leadership is a key aspect to continuously improving student activities and should encompass both student and non-student volunteers.

Volunteer Retention

Volunteers form the backbone of student activities at the annual EMBS conference. They must be able to take ownership of the professional development activities they plan and must be afforded a degree of flexibility in execution. Traditionally, two student leaders plan each session at the EMBS conference, which eases the workload and encourages new volunteers to participate. Support from the EMBS executive office and the student activities committee is a key aspect to retaining volunteers through encouragement, timeline management and solving administrative needs. Student leaders are recruited at each conference from institutions in the host city, or from volunteers that have developed or attended previous activities. Key positions, such as the chairs of the student activities committee and the EMBS Student Representative, maintain at least two years of continuity.

Implications for Undergraduate and Graduate Curriculum Planning

Professional volunteer service teaches leadership, teamwork, and organizational skills in addition to helping provide a network of career resources and contacts. These are baseline skills required for success in modern day engineering. A tailored course in engineering management or professional skills to suit the needs of bioengineers addresses this need, and could be implemented with a requirement to perform academic volunteer work. The course may encompass and further develop the contents covered in the “Innovations and Entrepreneurship in Bioengineering” session of the 2007 conference.

Session topics covering an introduction to bioengineering and the related spectra of career and professional development opportunities could be integrated into course that showcases bioengineering at the undergraduate level. A discussion course on the legal, political, ethical, and international socio-economic issues for bioengineers along the lines of the 2007 session titled “Biomedical Engineering and Society” would serve to teach students to appreciate the broader impact of the profession.

Participation in the conference as a volunteer-leader or as a student panelist cultivates communication skills. These skills are translatable to the effective description of a student’s research in a paper, oral presentation or poster. Communication skills remain critical when applying for scholarships, independent research grants, and business funding opportunities. Thus, a course requiring students to present their work or critique a paper in the form of a journal club would be very beneficial for career development.

Contextual Analysis of Implications

We believe that our conference efforts devoted to career and professional development are aligned with the vision of ABET, NAE, and NSF. All of the topics covered in our sessions address at least seven objectives of Criterion 3 for Engineering Programs¹. Accredited educational institutions must demonstrate that their students attain these objectives, which may be difficult to incorporate into traditional classroom teaching.

1. *An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, and sustainability.*
2. *An ability to function on multi-disciplinary teams.*
3. *An understanding of professional and ethical responsibility.*
4. *An ability to communicate effectively.*
5. *The broad education necessary to understand the impact of engineering solutions in a global and societal context.*
6. *A recognition of the need for, and an ability to engage in life-long learning.*
7. *A knowledge of contemporary issues.*

Furthermore, our efforts are also streamlined to encompass all of the focal attributes outlined for engineers and technologists by the NAE², including the development of:

1. *Broadly synthesizable multi-disciplinary creativity.*
2. *Good listening ability along with effective communication through oral, visual, and written mechanisms.*
3. *An appreciation of the link between technology and socioeconomic foundations of modern society.*
4. *Effective leadership through sound understanding of foundational principles.*
5. *High ethical standards.*
6. *Strong sense of professionalism.*
7. *Functional dynamism, agility, resilience, and flexibility.*
8. *Imperative lifelong learning capacity.*

Additionally, the student activities committee is committed to effectively communicate the following critical investment priorities of the NSF, as laid out in the agency's current Strategic Plan³, at the EMBS conferences:

1. *Investigate the human and social dimensions of new knowledge and technology.*
2. *Foster research that improves our ability to live sustainably on Earth.*
3. *Prepare a diverse, globally engaged science, technology, engineering, and mathematics workforce.*

The visions of ABET, NAE, and NSF serve to stimulate not only professional development, but also social and leadership skills. As our student tracks have evolved to meet the demands of the 21st century bioengineer, our visions, too, have focused on these topics, putting our sessions inline for incorporation into the engineering curriculum.

Future Work

The present qualitative outcomes of the student activities programs in the context of volunteer retention and creative sustainability are positive and encouraging. However, there exists a need to assess the statistical robustness of the feedback related to the functionality and reach of our conference initiative. Data collection is being planned for future conference initiatives for evaluating specific outcomes including in terms of the objectives of ABET, NAE, and NSF. Similarly, specific academic programs may be approached for assessing the potential of integrating our conference enterprise as an intra-curricular or extra-curricular enterprise. While the implementation of our conference activities in an educational institution may not be a direct requirement of any accrediting institution, students exposed to career and professional development activities will nonetheless emerge better prepared for the workforce and professional challenges. The potential of designing an Internet-based distant education or an audio-visual professional training program also appears as a promising opportunity.

Conclusion

The student activities committee of the IEEE EMBS has been successful in maintaining a holistic perspective and developing a strong supplement for mainstream educational endeavors oriented toward improving the professional development capabilities and competencies of graduating bioengineers. Our perspective complements the visions of the engineering programs and strategic plans put forth by the ABET, NAE, and NSF. Through the incorporation of the student sessions into courses at both the undergraduate and graduate levels, students would become versed in topics relating to professional development, volunteerism, and associated social, ethical, legal, political, and global issues. This would put the students on the path to becoming successful and socially conscious bioengineers in the 21st century.

Bibliography

1. Criteria for Accrediting Engineering Programs 2008-2009, ABET: Engineering Accreditation Commission, Baltimore, Maryland, USA, URL: <http://www.abet.org>
2. *The Engineer of 2020: Visions of Engineering in the New Century*, The National Academies Press, Washington, DC, 2004

3. National Science Foundation Investing in America's Future *Strategic Plan FY 2006-2011*, URL: <http://www.nsf.gov/pubs/2006/nsf0648/nsf0648.jsp>
4. Madhavan G, Oakley B, Kun L, [Eds], *Career Development in Bioengineering and Biotechnology*, Springer, New York, 2008
5. Institute of Electrical and Electronics Engineers, URL: <http://www.ieee.org>
6. Engineering in Medicine and Biology Society, URL: <http://www.embs.org>