AC 2008-2958: DEVELOPMENT OF A BIOENGINEERING CONCENTRATION IN THE DEPARTMENT OF CHEMICAL ENGINEERING AT PRAIRIE VIEW A&M UNIVERSITY: OUTCOMES AND LESSONS LEARNED

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Development of a Bioengineering Concentration in the Department of Chemical Engineering at Prairie View A&M University Outcomes and Lesson Learned

Abstract

With the daily advances in biotechnology, the increasing importance of nanotechnology and exponential demand for a more skilled biotech/nanotech workforce, many universities are updating their curriculum in order to graduate students better prepared to enter and compete in the new global marketplace. The Department of Chemical Engineering at Prairie View A&M University (PVAMU) has made strategic efforts to develop a concentration in Bioengineering, hiring new faculty, increasing research capacity in the bioengineering area, developing a course, and seeking collaborations within the university and with external collaborators. With the ever growing emphasis on the synergy between biology and engineering, it is paramount that PVAMU also update its program and curricula in order to remain competitive and be a major contributor to the biotechnology workforce. To this end, increasing the number of bioengineering programs at minority serving institutions is necessary if the science and technology community are to meet the ever growing needs of the biotechnology and nanotechnology workforce. The objective of this paper is to discuss the outcomes and lessons learned in the development of a bioengineering concentration in the Department of Chemical Engineering at Prairie View A&M University.

Introduction

With the emergence of newer technologies, many of which steeped deeply in chemical engineering principles, the chemical engineering profession has witnessed a decline in the number of students choosing it as a field of study.[1-3] Whereas there are a number of factors that contribute to the enrollment decline, the shift of students who would normally pursue careers in chemical engineering degrees to bio-related departments (i.e. biomedical, biological, bioengineering, etc.) has had an significant impact.[3] To address this issue, many chemical engineering programs have changed their names and updated their curriculum to reflect the shared focus on biology and engineering.

Worldwide, the fastest growing global biotechnology marketplace includes approximately 4300 companies in 25 nations with revenues estimated at over $40 billion.[4] The biotechnology industry clusters have identified workforce development as the second or third largest hurdle to commercialization and economic success.[5] Hence, the survival, maturation and success of the biotechnology industry is ultimately linked to the ability to not only hire and retain a workforce that possesses skills and fundamental knowledge in traditional areas of biochemistry, molecular biology, pharmacology, engineering and chemistry, but also the ability to apply this knowledge to solve fundamental nano-scaled –bioengineering problems. Given the daily advances in biotechnology, the increasing importance of nanotechnology and exponential demand for a more skilled biotech/nanotech workforce, it is imperative that university curricula is reflective of market shifts (while maintaining the fundamental principles) in order to graduate students better prepared to enter and compete in the new global marketplace.

HBCU's are doing their part to help the US meet the need of replenishing the engineering pipeline despite limited federal support.[6] Many HBCUs lack the resources to quickly implement curriculum changes to focus on emerging technologies. Furthermore, faculty at many HBCUs developed their research focus before the evolution of biotechnology and transitioning to new research areas, particularly with the high teaching loads and lack of facility infrastructure, can be quite challenging. Currently, there are twelve (12) Historically Black College and University's (HBCU) that have Engineering programs accredited by the Accreditation Board for Engineering and Technology (ABET). The Department of Chemical Engineering at PVAMU is one of only six chemical engineering programs at an HBCU. Of the six, only two programs have updated their curricula to reflect the shared focus on biology and engineering. FAMU, a public institution, has changed its name to the Department of Chemical and Biomedical Engineering and Tuskegee, a private institution, has added concentrations to its curriculum. With the ever growing emphasis on the synergy between biology and engineering, it is paramount that PVAMU also update its curriculum in order to remain competitive and be a major contributor to the biotechnology workforce.

The Department of Chemical Engineering (ChE) at PVAMU graduates students well-trained and prepared to enter the engineering workforce and/or pursue further studies in graduate school in the traditional areas of ChE. Based on thoughtful consideration of the future technological and scientific needs of the Department, College, US workforce, and the profession in general, we concluded that it is paramount our educational efforts align with the skills and knowledge relevant to our nation's needs. If bio-nanotechnology is the way of the future then the need to be prepared cannot be over emphasized. This paper describes the steps taken by the department to develop a bioengineering concentration, outcomes, and lessons learned.

Methods

Faculty Recruitment

Over the past seven years, the Department has made strategic efforts to expand its capabilities in the bioengineering area. Prior to this period, the department was comprised of five (5) faculties, whose area of expertise was tertiary oil recovery, engineering optimization, and process safety. In 2001 and 2003, two new faculties were hired to support the departments shift in focus and develop the Bioengineering concentration program. The first faculty is a Biochemical engineer whose area of expertise is in bioprocess engineering and biocatalysis. The second faculty is a Chemical engineer whose area of expertise is in bioseparations. With the addition of the new faculty, the department has been able to successfully augment the existing curriculum and supplement the courses with bioengineering principles and increase student interest in course and research opportunities in this area.

Facility Infrastructure and Research Capabilities

With the increasing interest in bio-related courses and research experiences as well as the new faculties focus to develop the bioengineering concentration, the initial focus was to increase the equipment and instrumentation infrastructural capabilities of the department. Small, less expensive equipment was purchased with departmental funds and start-up research grants provided by PVAMU Office of Research and Development. These efforts lead to the faculty being able to successfully secure funding from the National Science Foundation (NSF) Major

Research Instrumentation Grant (NSF #0421287 Major Research Instrumentation Grant: Acquisition of research instrumentation for applied research and training in biotechnology and bioprocess engineering) and the subsequent purchase of equipment needed to conduct fundamental research. The equipment purchased with this grant allowed the department to increase the number of undergraduate research opportunities and thus increase student interest in bio-related topics. Additionally, the increased infrastructure positioned the department to partner with other larger institutions (i.e. University of Kansas, University of Iowa, University of California-Berkeley, Harvard, etc.) and successfully secure NSF funding of two (2) Education Research Centers (Center for the Environmentally Beneficial Catalysis (CEBC) and Synthetic Biology Engineering Research Center (SynBERC)) and purchase more laboratory instrumentation.

Research opportunities for both graduate and undergraduate students have increased with the hiring of the new faculty and purchase of equipment and instrumentation as shown in Table 1. Notably, the students conducting undergraduate research represent approximately 80% of the undergraduate students conducting research in the department of chemical engineering.

Table 1. Baseline Data for Research Participation in Biotechnology

Activity	2007	2006	2005	2004	2003	2002
Undergraduate Research in Bioengineering	8	12	12	8	4	1
Graduate Research in Bioengineering	1	2	2	1	1	-

Finally, in 2006, the department was awarded the NSF Targeted Infusion Project to establish a bioengineering concentration within the department. This grant provided the last integral piece in providing the department of funding it needed in order to move forward. One component of the grant focused on purchase of laboratory equipment and re-design of undergraduate chemical engineering lab 1.

Curriculum Development

The current Chemical Engineering curriculum is designed to prepare engineers who are well qualified to design and operate chemical processes. The undergraduate baccalaureate degree requires that students complete 138 hours, of which 20 hours of chemistry and 42 hours of chemical engineering specific courses. The Bioengineering option will require that students complete 20 hours of course materials, of which 17 hours are integrated into the current curriculum, specific to bioengineering concepts, which is spread amongst the current chemistry and chemical engineering requirements and is detailed in Table 2 below. The courses were selected that would build the students knowledge, skills, and expertise in basic fundamental bioengineering concepts. Students choosing the Bioengineering option will thus complete 141 hours for an undergraduate baccalaureate degree in chemical engineering. Additionally, bioengineering concepts are being vertically and horizontally integrated throughout the chemical engineering curriculum. The concentration requirements were outlined from examining other programs with bio-related options. Hence, the requirements are aligned with programs other national and regional universities of similar and larger size and mission statements. The course requirements are the following:

Table 2. Course Requirements for Bioengineering Option	
Courses	Hours
Biology	**3**
Biochemistry	**3**
Biochemistry Lab	**2**
Bioengineering Technical Elective (2 courses)	**6**
Senior Design I & II (Bioengineering project)	**6**
Total Hours	**20**

The growth of activities related to biotechnology and bioprocess engineering classroom and laboratory experience based instruction is represented in Table 3. The technical elective course, CHEG 4103, was introduced in 2002 with significant interest and has persisted over the three years. The course was originally introduced as a Special Topic course; however, the department has submitted the necessary paperwork to add this course to the Chemical Engineering inventory as a stand alone course effective fall 2008. CHEG 4153 is a course that is in the course inventory but has not been taught for several years. The course was updated and taught in spring 2008. Enrollment data for this course is also presented in Table 3 below.

Table 3. Baseline Data for Course Enrollments							
Activity	**Course Number**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**
Intro to Biotechnology & Bioprocess Engineering*	CHEG 4103	-	-	13	9	-	10
Bioengineering	CHEG 4153	10	N/A	N/A	N/A	N/A	N/A

Concentration Approval

Once the curriculum requirements were outlined, the Department moved forward to secure approval of the concentration through the process outlined by Prairie View A&M University. In order to establish a concentration at PVAMU in the COE, the Department must first receive approval of any curricula changes from the COE Curriculum Review Committee (CRC). Once approved by the CRC, the department must then submit necessary paperwork to for review by the University Curriculum Review Committee (UCRC). Once this process has been approved, paperwork is submitted to the Texas A&M University System Coordinating Board for final approval.

Discussion

The Department of Chemical Engineering has made steady progress toward final approval to offer a Bioengineering option. The current Chemical Engineering curriculum has been restructured to accommodate offering a Bioengineering option and approved by all faculty in the department. The request to offer a Bioengineering option in the Department of Chemical Engineering has been approved by the College of Engineering curriculum committee and the

University Academic Council (UAC). The request will be forwarded to the Texas A&M University System Coordinating Board for final approval. If approved, the Bioengineering concentration will have an effective date of fall 2008.

The request to add a course and modify an existing course as inventory for the Bioengineering option has been approved by the UAC and is being forwarded for final approval by the Texas A&M Coordinating Board. The request included adding CHEG 3153- Introduction to Biotechnology and Nano-Scaled Processes to the course inventory and updating the course description of CHEG 4153-Bioengineering (2nd course in sequence). A new "Special Topics" course was offered in fall 2007 entitled "Introduction to Nanotechnology". The "Bioengineering" course was taught this semester for the first time in five (5) years with an enrollment of 10 students. Being one of only two electives that were offered by the department this semester.

Lessons Learned

One of the most important lessons learned was that we did not adequately anticipate the amount of time and human resources that would be needed in order to implement the bioengineering concentration. For this reason, it has taken longer than originally estimated in order to accomplish the measures that have been completed to date. PVAMU is primarily a teaching institution, hence our normal teaching load is four course (or 12 credit hours) per semester. However, there is a focus on increasing the amount of research conducted by faculty within the College of Engineering. Additionally, maintaining student interest and being able to recruit new students has become challenging. Although we are able to introduce the concepts in new courses and existing courses, it is often difficult to keep up with the expanding interest of the students and almost impossible to do any active recruiting of new students. Given these factors combined with the fact that the new faculty hired to develop the bioengineering program are Assistant-level faculty, having additional human resources was needed in order to further distribute the task associated with the new concentration.

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