

AC 2007-1824: COLLABORATIVE EFFORTS FACILITATE THE GROWTH OF AN INTERDISCIPLINARY MINOR IN BIOTECHNOLOGY

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Collaborative Efforts Facilitate the Growth of an Interdisciplinary Minor in Biotechnology

Abstract

Tremendous advances are being made in pharmaceutical and biotechnology discoveries and their applications (including manufacturing), as well as in health care services. As a result, there is an increasing sophistication of the products and services available and being developed, with an ever-widening scale of applications and marketing. The growth of biotechnology results in ever-expanding needs for college graduates who have knowledge of life-science based products and processes. There have been numerous reports of current and projected shortages of human resources possessing the required knowledge in the growing industry. In order to address the gap between education and the workforce, the Department of Industrial Technology has developed an academic minor in biotechnology being implemented in fall 2004.

This interdisciplinary biotechnology initiative is the result of a partnership among the Department of Industrial Technology, the Department of Biology, and the Department of Pharmacy. The program is administered within the Department of Industrial Technology. The minor is taken while the student continues his/her academic field of study and is made up of the following courses: Fundamentals of Biology, Molecular Biology and Genetics, Cell Biology, Biotechnology Laboratory courses, Compliance, Process Quality Control, and Bioinformatics Technology. The minor is available to any ---- University student majoring in any four-year degree baccalaureate degree program, i.e., science, technology, agriculture, pharmacy. The purpose of the minor is to offer the graduates of these four-year programs the basic knowledge and understanding of life-science based products, processes, and product quality to seek employment opportunities in the area of biotechnology and biotech-manufacturing. The biotechnology minor aims to provide a University-wide opportunity for undergraduates to acquire the knowledge and aptitudes needed in the biotechnology industry. The objectives of this paper are to describe the collaborative efforts and curriculum development that integrate the biotechnology minor into majors within multiple disciplines, including Industrial Technology.

Introduction

Indiana's health industry is an extremely important and growing economic engine. Tremendous advances are being made in pharmaceutical and biotechnology discoveries and their applications (including manufacturing), as well as in health care services. As a result, there is an increasing sophistication of the products and services available and being developed, with an ever-widening scale of applications and marketing. This results in ever-expanding needs for college graduates who have knowledge of life-science-based products and processes. There have been numerous reports of current and projected shortages of human resources possessing the required knowledge in the growing industry.¹ As reported in the meeting summary for the Pan-Organizational Summit on the U.S. Science and Engineering Workforce, technical skills combined with a strong math and science background and integrated with problem-solving, critical-thinking, and

teamwork skills are sorely needed by modern manufacturing as well as by other sectors.² The need for an educated workforce in biotechnology manufacturing also exists beyond Indiana as illustrated by the following quotes from Science magazine.

- *“The biotechnology industry is still in its adolescence, but it is about to have a major impact on health care. A third of drugs in phase III clinical trials are proteins...biotech companies are gearing up to manufacture product but they face a shortage of talent”*³
- *“Biopharmaceutical companies are pushing their existing staff to the limits to meet [demand],”*⁴
- *“Biotech is getting bigger. And the next challenge facing the industry is learning how to scale up its therapeutic protein manufacturing facilities. Today’s plants just don’t supply current demand, and that demand is set to rise sky high...the potential rewards for scientists with the skills to help it meet its growing need are equally high...there is a consensus among recruitment specialists that there is likely to be shortage of qualified people. Already, supply ‘is far from meeting the demand,’ agrees Nicolas Hollanders, a recruitment consultant specializing in biotechnology.”*⁵

In order to prepare students for the emerging changes in biotechnology industry, --- University has recently approved the minor in Biotechnology, an interdisciplinary effort among the College of Technology, the College of Science, and the College of Pharmacy. Through this partnership, laboratory activities were implemented in Fall 2004 to educate and train the students currently enrolled within this program. The unique niche of this program is the focus on both biotechnology manufacturing and interdisciplinary research. Interdisciplinary research was defined by the Committee on Science, Engineering and Public Policy at the National Academy of Science as *“a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding to solve problems whose solutions are beyond the scope of a single discipline or area of research practice.”* The committee also viewed interdisciplinary education as *“a central component of interdisciplinary research by encouraging students to understand and pursue multiple disciplines and to address complex problems from the perspective of multiple fields.”*⁶ Students that learn within an interdisciplinary environment will be better equipped to address the evolving needs of the biotechnology industry.

Therefore, courses that are a part of the biotechnology curriculum provide education on skills unique for life sciences manufacturing. The biotechnology labs cover several techniques employed in biotechnological research and emphasize experimental design, technical applications and the use of appropriate instrumentation. Graduates of the biotechnology program are unique because they have both manufacturing and scientific research expertise that will enable them to meet the rising demand by industries for individuals educated to manufacture biological products on an industrial scale.

Connection between Purdue University’s College of Technology Strategic Plan and the Biotechnology Program

The biotechnology program helps support the strategic plan for ---- University by improving the learning environment for students and encouraging interdisciplinary research connections among students and faculty. In addition, the program helps harness ----’s strengths in life sciences and technology by providing graduates that will help ---’s future growth and development in biotechnology. As stated in the strategic plan⁷, The College of Technology educates professional practitioners and managers of science and engineering-based technologies and community leaders, accelerates technology transfer to business and industry, and develops innovations in the application of emerging technology through learning, engagement, and discovery.

To fulfill its mission, the College of Technology strives to “*provide a student-centered learning environment to ensure that graduates are accomplished in technical expertise, leadership, and teaming skills necessary to excel in the global technological economy.*” The College of Technology strategic plan also puts importance on “*...support for programs that foster the development of innovative instructional strategies, curriculum and laboratory development...*” The biotechnology program is an example of a forward-thinking effort that helps fulfill the mission of the College of Technology. Four signature areas have been identified by the College of Technology and the biotechnology laboratory courses enhance learning, discovery, and engagement within these areas:

Technology and Life Sciences

- Engage students in hands-on genomic, proteomic and bioinformatics life science applications within the biotechnology laboratory

Security and Forensics

- Learn the biological basis for the routine processes conducted in a forensics laboratory

Advanced Manufacturing

- Learn life science skills coupled with manufacturing knowledge to prepare them for manufacturing biologically active (life-science based) products within biotechnology industries

Workforce Development

- Prepare graduates to achieve the integration and effective use of life science technology in the area of biotechnology through laboratory-based instruction and equip them to become life-long learners

The Industrial Technology program within the College of Technology is designed to prepare students in both technical and management areas. Graduates are best suited for

technical and/or managerial positions in business, industry and government. Course work includes production planning, industrial ergonomics and safety, quality control and productivity, manufacturing facilities planning and material handling, automated manufacturing systems, automatic identification and data capture, and computer simulation. The minor in biotechnology can be integrated with the focus areas within the Industrial Technology program to prepare graduates for analogous positions within life science based industries.

Principles of continuous improvement, such as Lean Manufacturing and Six Sigma, provide an example of the complementation between the curriculum within Industrial Technology and the Biotechnology program. Pharmaceutical companies are beginning to use Six-Sigma and Lean Manufacturing within their operations. In fact, a recent report in Genetic Engineering News stated, *”The successes of Six Sigma, Lean, and similar operational excellence strategies are legendary in heavy manufacturing. Pharmaceutical and biotech companies were slow to catch on, but today, nearly every company has jumped on the bandwagon.”*⁸ The integration of the Biotechnology minor with Industrial Technology provides the basic knowledge and understanding of life science-based products, processes, and product quality and produces graduates that will be the vanguard of a highly educated workforce for the biotechnology industry.

Biotechnology program represents multiple disciplines

The biotechnology program was implemented in Fall 2004 and three courses have been developed and offered solely for the biotechnology program: Biotechnology Lab I (IT226), Biotechnology Lab II (IT227) and Introduction to Bioinformatics (CIT 227). Students from several departments within the College of Technology and also from the College of Science, College of Pharmacy and College of Agriculture benefit from the curriculum within this laboratory course and are actively participating within the minor. The program is administered by the Department of Industrial Technology, but the courses within the minor are taught by faculty from multiple departments. The biotechnology courses listed below in Table1 reflect the collaborative nature of the program.

Table 1: Biotechnology courses within the minor

Course Number	Course Name	Department
BIOL 112	Fundamentals of Biology I	Biology
BIOL 113	Fundamentals of Biology II	Biology
BIOL 241	Biology IV: Genetics and Molecular Biology	Biology
BIOL 295E	The Biology of the Living Cell	Biology
IT 226	Biotechnology Lab I	Industrial Technology
IT 227	Biotechnology Lab II	Industrial Technology
CPT 227	Introduction to Bioinformatics	Computer and Information Technology
IPPH 522	Good Regulatory Practice	Industrial and Physical Pharmacy
IT 342	Introduction to Statistical Quality	Industrial Technology

The students that are participating within the biotechnology minor also represent multiple disciplines. As shown in Table 2, the program continues to grow in size and attract students from multiple departments across campus.

Table 2: Students participating in the minor and their college

College	Number of students
Agriculture	1
Engineering	1
Liberal Arts	2
Management	5
Pharmacy	10
Science	15
Technology	13
Graduate	2

Collaborations with other programs, departments and centers on campus have been instrumental to the growth of the program. Most significantly, a recent partnership with - ---- Bioscience Center at Discovery Park has provided research laboratory space for the biotechnology laboratory courses. ----University’s Discovery Park is an administrative unit outside the traditional academic departments that is a model for the conduct of interdisciplinary discovery, learning and engagement with society. The ---- Bioscience Center (BBC) at Discovery Park blends life sciences and engineering research to cultivate and support innovative, multi-investigator, interdisciplinary research teams. BBC engages biosciences in a broader perspective with applications of new or emerging technologies. The Center has established new research infrastructure to apply analytical methods, precision measurement technologies and high throughput approaches to biological systems. BBC research activities are organized around four Research Core facilities in which multiple high-end technologies are applied to biological systems in the context of senior BBC research scientists with deep expertise in these technologies. A major push is to assemble the requisite expertise to apply and develop technologies for a fuller approach to the complexity of biological systems.

The collaboration of the Biotechnology program with the BBC at Discovery Park has facilitated the incorporation of authentic, interdisciplinary, biotechnology research projects into the core curriculum of the biotechnology program. In addition, the partnership enables the BBC to impact undergraduate student education and engage the students in cutting-edge research and the development of new technology. The integration of the BBC and the Biotechnology program is highlighted below in Figure 1.

**Cellular
and
Molecular
Biology**

**Good
Regulatory
Practice**

**Statistical
Quality**

Figure 1: Collaboration between ---- Bioscience Center and Biotechnology program

Biotechnology laboratory activities consist of bioinformatics modules, hands-on laboratory research activities at ---- Bioscience Center, critique of scientific journal articles and creative writing activities. Future activities will expand the number of biotechnology laboratory research projects integrated into the classroom and implementation of hands-on laboratory activities and current case studies within the good regulatory practice course to address the regulatory aspects of biologics.

Impact of Biotechnology Lab I

Biotechnology Lab I is a 2 hour course intended for undergraduate students and serves as a prerequisite for Biotechnology Lab II and Introduction to Bioinformatics, courses that compose the new core curriculum in the biotechnology program. There are no prerequisites for Biotechnology Lab I, the initial course within the biotechnology program. Biotechnology Lab I serves as one of the primary entry points into the biotechnology program and also has a direct impact upon Biotechnology Lab II and Introduction to Bioinformatics (Figure 1). In an effort to expand the program and generate student enthusiasm for the minor, the Biotechnology Lab I course has been integrated into other programs on campus. The core curriculum for the biotechnology program has been evolving to meet the needs of existing programs on campus. This has helped create a niche for the minor in Biotechnology and facilitated its integration with multiple majors. Collaborations with other programs have been instrumental to the growth and development of the Biotechnology program. Two of these programs are highlighted below.

1. Undergraduate Certificate in Entrepreneurship and Innovation

The Undergraduate Certificate in Entrepreneurship and Innovation is available to all ---- University undergraduates in any major. The program is designed to offer students:

- The skills necessary to be a successful entrepreneur, be it in a start-up venture, small business, or large organization
- An understanding of the role of entrepreneurship in the U.S. and world economies
- A sense of their aptitude for entrepreneurship through education and a hands-on component.

Students seeking the Entrepreneurship and Innovation Certificate must complete a sequence of 5 courses (15 credits). These include two required core courses, two option courses in areas of their choice, and one capstone or project-based course. The Biotechnology Laboratory I (IT226) course within the Biotechnology program is offered as an option course for the Entrepreneurial program. Biotechnology Lab for Entrepreneurs (IT226E) provides hands-on experience with the latest biotechnology equipment via the collaboration discussed above with Bindley Bioscience Center. The course also incorporates guest speakers from biotechnology industries and academia that share their experience with the students. For students interested in entrepreneurship, the biotechnology course provides the experiences that enable the student to

- understand the current trends and emerging technology within the biotechnology industry
- identify where gaps exist between current technology needs and existing solutions
- recognize existing gaps between biotechnology needs and current solutions as opportunities
- explore potential solutions for new technology development to address identified needs within the biotechnology industry.

The learning objectives stated above are assessed by student completion of an electronic portfolio that includes writing activities and projects. In addition, students learn interpersonal skills by working on interdisciplinary teams in order to complete their practical laboratory activities.

2. Forensic Science Minor

The focus of the forensics program at ----- University is the training and research of those areas of forensic science that deal with crime-scene investigation, the collection, processing and interpretation of physical evidence, and the presentation of this evidence pertinent in the criminal justice system. There is an increasing demand for professionals trained in the discipline and techniques of forensic science; not only in traditional crime investigation but also in the spectrum of world terrorism and homeland security. -----'s program in forensic science is built on a solid foundation of courses in biological, chemical, and physical sciences, including a series of courses specific to forensic science

and criminalistics, computer forensics, forensic entomology, forensic microscopy, environmental and health sciences, law and society, psychology, aviation technology, engineering a host of other courses related to forensic science education. The curriculum within the biotechnology program provides a molecular understanding and hands-on experience in molecular techniques that are commonly utilized in forensic laboratories. The Biotechnology Laboratory I (IT226) is an elective for the forensic minor.

Evaluation of Biotechnology Lab I and Biotechnology Lab II

The goals of the biotechnology core curriculum are to create an environment that encourages interdisciplinary learning with students from multiple disciplines in order to enhance learning, creativity and knowledge transfer. Based upon the preliminary data, the learning environment is supportive of the goals stated above. A Small Group Instructional Diagnosis (SGID) was conducted by the Center for Instructional Excellence at ----- University after the spring 2006 semester to determine what components of the curriculum were effective and what components of the curriculum were ineffective. The results of the SGID for Biotechnology Lab I and II are indicated below in Tables 3 and 4.

Table 3: Small Group Instructional Diagnosis (Biotechnology Lab I: IT 226)

I. What do you like about this course?	
<i>Course Organization and Structure</i>	The lab experiments are well designed; there is updated technology used in the lab; the course is cohesive with other courses (e.g., reinforces topics that were discussed in genetics classes)
<i>Course Content</i>	Course covers a wide range of topics
<i>Instructor Characteristics</i>	The instructor is knowledgeable, available, and cares about the students
<i>Teaching Techniques</i>	The homework is a good review of the content; the lab has a good pace
<i>Evaluation and Grading</i>	The exams are low pressure and they focus on communication, thinking, and application within the field
II. What specific suggestions do you have for changing this course?	
<i>Course Organization and Structure</i>	Have a better defined syllabus; have all protocols in one manual; better prepare students for the lab; give students the packet in the lecture preceding the lab; assure that students with no or little biology background are brought up to speed for the background knowledge in biology that is needed for the course; it should be offered as a major

Table 4: Small Group Instructional Diagnosis (Biotechnology Lab II: IT 227)

III. What do you like about this course?	

<i>Course Organization and Structure</i>	The class size is small
<i>Course Content</i>	Course uses current lab technologies and techniques and current projects; course provides students with different aspects of the content (theory arrow application arrow industrial application); DNA purification lab was helpful as students learned a new technique (a senior student pointed out not having had learned the technique prior to the lab)
<i>Instructor Characteristics</i>	Instructor is easy to contact via email and responds quickly to email; instructor explains well
<i>Teaching Techniques</i>	Course requires students to utilize different sources to find information; students learn to use the sources that are used by professionals in the field; students are encouraged to think outside the box and to use their creativity
IV. What specific suggestions do you have for changing this course?	
<i>Course Organization and Structure</i>	Use WebCT more often and provide students with a more detailed syllabus; don't require the book for class; provide students with copies or PDF files of the required reading materials; assure that the students have the needed Biology background knowledge for the course; establish prerequisites and/or have a test that students need to pass to demonstrate sufficient background knowledge in Biology; provide a standardized way for getting credit for IT 226; Fine-tune the lab materials to increase the likelihood of students obtaining the desired results for their lab experiments; better prepare students for the lab especially at the beginning of the semester
<i>Evaluation and Grading</i>	Give ungraded/bonus quizzes that allow students to see how well they understand the material; provide clearer directions for the assignments; clarify the criteria and standards that will be used to grade the assignments

The feedback from the SGID is encouraging and overall the students report that the learning environment stimulates creativity and engages them with relevant technology within the field of biotechnology. However, the results from the SGID also highlight some of the challenges that have been encountered and point out the need for continual improvement.

Future Directions

The Biotechnology Lab I course has no prerequisites and based upon the feedback from the SGID, more theory must be provided prior to the hands-on activities in order to ensure that students from all disciplines feel prepared and knowledgeable. Many different textbooks have been tried, however, an appropriate textbook has not been found that truly integrates the life sciences with technology. Currently, the instructor is developing a laboratory packet that will provide the appropriate background theory for

the interdisciplinary research projects. In addition, students appreciate the use of high technology in the classroom and thus the instructor is also working on developing virtual reality modules for instruction and integrating the laboratory packet with online tutorials, animations and quizzes. Finally, based upon the success of the initial collaborations and partnerships, the instructor will also continue to actively pursue collaboration with other complementary programs on campus.

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