AC 2008-1121: INTRAMURAL RESEARCH INTERNSHIP: A REQUIREMENT OF THE UNDERGRADUATE BIOENGINEERING CURRICULUM AT THE UNIVERSITY OF PITTSBURGH

Steven Abramowitch, University of Pittsburgh

Dr. Abramowitch is an Assistant Professor of Bioengineering at the Swanson School of Engineering at the University of Pittsburgh. He received his B.S. (1998) in Applied Mathematics and Ph.D. (2004) in Bioengineering from the University of Pittsburgh. Currently, he serves as the Director of the Tissue Mechanics laboratory in the Musculoskeletal Research Center.

The primary goal of the Tissue Mechanics Laboratory is to understand and enhance ligament healing utilizing functional tissue engineering approaches, and to investigate mechanisms of pelvic floor failure in women with pelvic organ prolapse.

Dr. Abramowitch served as course instructor for the Intramural Research Internship course from 2004-2007.

Mark Redfern, University of Pittsburgh

Dr. Redfern is Professor and Associate Chair of Bioengineering at the Swanson School of Engineering with secondary appointments in Otolaryngology and Rehabilitation Science at the University of Pittsburgh. Dr. Redfern received his B.S. in engineering science and applied mechanics at the Univerisy of Michigan in 1974, and his M.S. and Ph.D. degrees in bioengineering from the University of Michigan in 1988. He trained at New York University in clinical prosthetics, and was a certified clinical prosthetist for 4 years. His research areas are focused on biomechanics, human postural control, and ergonomics.

Richard Debski, University of Pittsburgh

Dr. Debski is an Associate Professor and undergraduate coordinator in the Department of Bioengineering. Additionally, he serves as the Co-Director of the Shoulder Dynamics and ACL Laboratories as well as the Director of the Robotics Group in the Musculoskeletal Research Center. He received both his B.S. (1991) and Ph.D. (1997) in Mechanical Engineering from the University of Pittsburgh.

The primary goal of the Shoulder Dynamics Laboratory is the study of shoulder instability -specifically, the structure and function of the ligaments and joint capsules at the glenohumeral and acromioclavicular joints.

Alejandro Almarza, University of Pittsburgh

Dr. Almarza is a Research Assistant Professor of Bioengineering at the Swanson School of Engineering at the University of Pittsburgh. He received his B.S. (2001) in Chemical Engineering and Ph.D. (2005) in Bioengineering from the Rice University. Currently, he serves as the Director of the Mechanobiology laboratory in the Musculoskeletal Research Center.

The primary goal of the Mechanobiology Laboratory is to understand the complex interactions between mechanical stimuli/forces and cellular behavior, along with utilizing molecular and cellular therapies, to enhance ligament healing. Major efforts are currently focused on the application of bioscaffolds to enhance ligament and tendon healing through functional tissue engineering.

Dr. Almarza is serving as course instructor for the Intramural Research Internship course from 2007-Present.

Harvey Borovetz, University of Pittsburgh

Dr. Borovetz is professor and Chair of Bioengineering at the Swanson School of Engineering and the Robert L. Hardesty Professor of Surgery at the University of Pittsburgh.

Dr. Borovetz received his B.A. in physics from Brandeis University in 1969, and his M.S. and Ph.D. degrees in bioengineering from Carnegie Mellon University in 1973 and 1976, respectively. His research areas are focused on the design and clinical utilization of ventricular assist devices for adult and pediatric patients.

Savio Woo, University of Pittsburgh

Dr. Woo is University Professor and Vice Chairman for Research and Mentorships/Internships in the Department of Bioengineering. He received his B.S. (1965) and M.S (1966) degrees in Mechanical Engineering from Chico State College and the University of Washington, respectively. He also received his Ph.D. (1971) in Bioengineering from the University of Washington.

Dr. Woo is the Founder and Director of the Musculoskeletal Research Center (MSRC). This is a diverse multidisciplinary research and educational center where over 450 orthopaedic surgeons, bioengineering students and staff have studied and worked.

Dr. Woo's research interests include biomechanics; experimental, theoretical and numerical analyses of the nonlinear material properties of biological tissues and new nonlinear viscoelastic theories for soft tissue; homeostasis of ligaments and tendons and their change following decreased, as well as increased, levels of applied stress and motion, and the methods to enhance the healing of the tendon, ligament and meniscus.

Dr. Woo has been elected to the Institute of Medicine, The National Academy of Engineering and Academia Sinica. In 1998, he was the winner of the IOC Olympic Prize for Sports Medicine and the first Olympic Gold Medal in Nagano, Japan.

Intramural Research Internship: A Requirement of the Undergraduate Bioengineering Curriculum at the University of Pittsburgh

Abstract

Intramural Research Internship has been offered as a core Bioengineering course since the inauguration of the University of Pittsburgh's undergraduate Bioengineering degree program in 1998. The goal of this course is to provide a collaborative, interdisciplinary research experience that exposes students to pathways for graduate education and professional careers in bioengineering. By complementing the education acquired in the classroom, we have found that this experience is both beneficial and motivational. This paper provides an overview of our Intramural Research Internship course and some of the unique teaching strategies that have been successfully implemented over the past decade.

Introduction

Our approach to undergraduate education is to provide students with an opportunity to receive individualized training in bioengineering while meeting the following objectives.

> Objective #1: *Graduates will have a strong foundation in fundamentals of life sciences (biology and physiology), mathematics, engineering principles and the humanities.*
>
> *Objective #2: Graduates will have both a broad knowledge of the technical and social principles of bioengineering as well as a focused education in one concentration area within bioengineering.*
>
> Objective #3: *Graduates will be prepared for careers through educational experiences beyond the classroom, which will deepen an understanding of the technical and non-technical issues in bioengineering, process and design.*
>
> Objective #4: *Graduates will have required knowledge to meet postgraduate goals in industry, graduate school or medical school.*

In order to meet objectives #3 & #4, we believe that a research internship experience is essential for students to appreciate the need for engineering education outside the classroom, and to make better informed decisions about their future careers. Thus, unlike any other Bioengineering Department that we are aware of, we have made our intramural research internship course a requirement of our undergraduate curriculum. We generally offer this course to juniors such that their fundamental mathematics, chemistry, biology, and bioengineering courses can provide a sufficient basis for laboratory work.

With our undergraduate program now exceeding 150 students, the major challenges that stem from our decision to make this a required course are 1) providing a sufficient number of internship opportunities, and 2) finding projects that match students' interests. Fortunately, at the University of Pittsburgh, the Swanson School of Engineering is located within one city block of our world class School of Medicine and the vast clinical research facilities at the University of

Pittsburgh Medical Center. As a result, undergraduates are able to participate in research and patient care programs that are unmatched across the United States.
These include the extracorporeal membrane oxygenator (ECMO) program at the Children's Hospital of Pittsburgh. ECMO is a heart-lung bypass technology that is used to provide advanced life support for heart and lung function. Here our students can be trained to serve as a perfusion assistant to operate and conduct troubleshooting on equipment, record patient vital signs, perform anticoagulation tests, administer medications and blood products, and interact with the nurses and physicians. In this program, students are truly part of the team providing the highest level of care for pediatric patients in the intensive care unit.

Another exciting program is the clinical artificial heart program. This program offers students the truly unique opportunity to participate in the development and clinical utilization of circulatory support devices including ventricular assist device (VAD) and total artificial heart (TAH). From these experiences, students gain a unique perspective of what it means to be a bioengineer in a clinical setting.

Of course, students can also participate in research at any one of our world renowned research centers and laboratories including the Musculoskeletal Research Center (MSRC), McGowan Institute of Regenerative Medicine (MIRM), Hillman Cancer Institute, Human Engineering Research Laboratories (HERL), Brain Imaging Research Center (BIRC), Center for the Neural Basis of Cognition (CNBC), as well as a host of others. In total, these facilities house our department's 17 primary and more than 100 secondary faculty. The research performed by our growing faculty spans across our 3 undergraduate curricular concentrations (Cellular and Medical Product Engineering, Biomechanics, and Biosignals and Imaging) and currently provides our undergraduates with a sufficient selection of research opportunities to pursue.

The following sections provide an overview of our course, which includes both a laboratory and didactic component. The course is designed for students to meet specific milestones throughout the term in order to maintain progress and interaction with their faculty mentor. The didactic component also serves to provide information that enriches the student's research experience in the laboratory.

Enrollment

With a program of our size, adequate communication is the most important tool for meeting the challenges listed above. Our faculty are continually made aware of our internship requirements through email, whereby the course instructor will solicit descriptors of research opportunities which are then distributed to our undergraduates. In addition, our faculty and staff are invited to participate in our undergraduate research symposium at the end of every term. This is typically a large, well attended event that is supported by the Swanson School of Engineering in the form of posters and signage that are posted throughout campus.

To communicate with our students, our weekly undergraduate seminar serves as an excellent platform to disseminate necessary information to sophomores and juniors. Once per term, the course instructor discusses the requirements of the internship course and provides information on

the exciting programs available to them as well as the research performed by our faculty. Finally, the course instructor defines the etiquette for approaching faculty about a potential opportunity in their laboratories. At that point, students are responsible to obtain a research opportunity that matches their interest.

Despite all of this communication, however, it was often typical for a student to attend the first day of class having done very little on his/her own to seek out an internship opportunity. Thus, despite the fact that this is a required course, students must receive the permission of the course instructor in order to register for the class. Permission is granted upon the completion of an application form that is to be signed by the student and faculty research mentor (Appendix 1). This application defines the goals of the research project and the number of hours that student will commit to the project on a weekly basis. It also provides the course instructor with the necessary contact information to utilize throughout the term. This approach has provided significant motivation for students to actively seek an internship and begin a dialog with their faculty mentor during the semester prior to enrollment in the course.

Research Requirements

Students are required to spend a minimum of 9 hours per week in the laboratory for a 12 week period. This research can either be performed during the semester prior to course enrollment (e.g., during the summer) or during the concurrent semester. Projects must include biological and engineering concepts which necessitate the student to perform some form of analysis or design.

Two samples of a student's typical lab work week are included below (as written by the students) as well as a few examples of the research projects investigated by undergraduates.

Typical Work Schedules (unedited)

Student A
I work 10 hours a week as part of the medial collateral ligament (MCL) group at the Musculoskeletal Research Center. A breakdown of my typical work week is as follows:

Monday
8:00AM – 1:00PM
Lab work and experimentation
1:00PM – 2:00PM
Weekly MSRC Center meeting

Wednesday
8:00AM – 12:00PM
Lab work and experimentation

Prevalent experiments run during my lab work period include hydroxyproline and glycosaminoglycan assays, cell culture, histology preparation, Small Angle Light Scattering data collection and processing, and experimental design and planning. I use Microsoft Excel and MATLAB for data analysis.

Student B
I think in a given week my time is roughly spent:

(50%) Data Analysis: I use DMAS (tracker and reporter) to digitize strain markers almost every day I work. I also use EXCEL daily. I often use ABAQUS to calculate the strain across the Glenohumeral Capsule. Over the summer I used MATLAB to analyze my data.

(40%) Organize Data: I am creating a data binder for all the tests from the summer and I organized/burned all the soft files on DVD's. Sometimes I prepare handouts of the data for meetings.

(10%) Testing: I help set up/clean up on testing days. I also work the computer/video system during the reference strain configurations.

Examples of Projects Being Performed by Students

"Investigation of drag-reduction and molecular stability of aloe-based drag reducing polymers exposed to a variety of storage protocols"

Faculty Mentor: Marina Kameneva Ph.D.

- The student must apply fundamentals of fluid mechanics to determine drag reduction, viscosities, shear rates, etc., utilizing a flow loop with a capillary viscometer.

"Changes in Urethral Biomechanical Properties after Nitric Oxide and Muscarinic Antagonism"

Faculty Mentor: David Vorp Ph.D.

- The student must apply fundamentals of mechanics of materials to determine elastic modulus, circumferential stress, and beta stiffness of blood vessels utilizing a modified perfusion system.

"Photohaptic Edge Detection with Regenerative Feedback to Assist in Object Detection for the Visual Impaired"

Faculty Mentor: George Stetten M.D., Ph.D.

- The student must apply fundamentals of design as well as signal processing and analysis to develop, build, test, and debug such a system.

Course Overview

The didactic component of the course includes various exercises aimed at improving the students' ability to perform research and communicate about their work.

During the first week, students are asked to complete online modules that are designed to teach a set of professional skills related to the acquisition and use of information. These were developed by our School of Engineering Librarian and are based on standards from ABET, ACRL (Association of College and Research Libraries), and Middle States criteria. In addition, students are provided with training on laboratory safety, chemical hygiene, and blood borne pathogens through the Department of Environmental Health and Safety. Representatives from the Institutional Animal Care and Use Committee (IACUC) and the Institutional Review Board (IRB) also provide lectures discussing the establishment and responsibilities of these organizations. Finally, students are provided with a lecture on performing a literature search utilizing popular online databases. This prepares students for their first writing assignment, which is to provide a summary of five sources of literature that are relevant to their project.

During the next two weeks, students prepare and deliver the first of four presentations they will deliver throughout the term. The goal of the first presentation is to clearly and concisely explain the background and specific goals of their research. It is a 3 minute presentation in which the student is limited to only 3 slides. We have found that the limitation on the number of slides forces students to make decisions about which content is absolutely necessary to include in their presentations and helps them to realize the information that is critical to get their messages across to the audience. This is reinforced by providing index cards to the class so that students can critique each other by providing the speaker with 3 positive comments and 1 constructive criticism. The goal here is to have the students tell the speaker whether the audience was able to follow the presentation, and if not, why not.

The next set of lectures provides specific instruction on delivering a scientific presentation. These lectures are intentionally given after the first presentation so that students can compare and contrast these points with their own presentation and the feedback that they received from their peers.

For the midterm exam, students deliver a 10 minute presentation describing the background, specific goals, study design and methods for their project. Following the presentation, each presenter must answer a minimum of 3 questions that are asked by their peers. Again, by allowing their peers to ask questions, the students can better understand where their presentation might have lacked clarity and/or identify areas of confusion.

The next set of lectures provides specific instruction on writing a scientific paper. Following these lectures students are grouped into teams of 4 and asked to critique and grade anonymous papers that had been previously written by students in past semesters. Each group must present their findings to the class. Typically, the instructor chooses two examples (one "good" and one "needing improvement"). Generally, students seem to enjoy critiquing the work of others. Thus, this assignment serves as a relatively enjoyable interactive exercise that helps to inform students as to the expectations for their papers and the mistakes that are routinely made.

Approximately 4 weeks before the end of the term, students deliver their third presentation. For this presentation, the students must provide a 3 minute overview of their entire research project without the use of slides or note cards. The goal of this presentation is to force students to prepare a brief summary of their project that they could utilize at a job interview in response to a question about their internship. Generally, students are relatively uncomfortable giving this presentation. However, many have commented that this approach has helped them reduce their anxiety during the final exam because they have already committed the main messages and terminology to memory.

For the remaining few weeks, the instructor meets one-on-one with each individual student to discuss his/her performance in the course. A novel teaching strategy that we have implemented includes videotaping and reviewing all student presentations throughout the term. Each student receives a point-by-point critique from the course instructor while watching his/her presentations (Appendix 2). The instructor provides specific feedback on each presentation in terms of content, organization, and delivery. Finally, students receive a digital copy of their presentations along with written comments, which can be reviewed in preparation for the final oral exam. The student feedback to this approach has been extremely positive, and the faculty have also noted a significant improvement in the overall quality of presentations.

At the end of each term, the final oral exam of 10 minutes is delivered during the department's undergraduate research symposium. The audience consists of the undergraduate student body as well as the faculty from the Department of Bioengineering who help to evaluate each student's understanding of his/her research project from a bioengineering and biomedical perspective.

Interestingly, the feedback that has been received from student evaluations over the years has praised this approach. In fact, the requests to increase the number of presentations throughout the term far exceed those that suggest there are too many. We have found that increasing the number of presentations has also forced students to seek input from their faculty mentors on a more regular basis and motivates them to continue working on their projects in a timely fashion.

Evaluation

Students are evaluated based on the 4 oral presentations and 2 writing assignments on their research - the literature summary and final technical report. Individual student evaluations are provided by each mentor to assess laboratory performance (Appendix 3). The scores were weighted as follows:

Class Participation (5%)
Literature Report (10%)
Mid-term Exam (15%)
Overview/Summary Presentations (5%)
2-Page Abstract (20%)
Final-Exam (25%)
Mentor Evaluation (20%)

Results & Conclusions

We have assessed the students' opinion of this course via teaching surveys and surveys of our alumni. For our teaching survey, we were specifically interested in the responses to the following items: 1) The course has improved my ability to make effective oral presentations, and 2) The course has improved my ability to write reports effectively. Over the two semesters prior to the implementation of the approaches described in this paper, the students provided scores of 4.1±0.2 and 3.7±0.2 out of 5 (mean ± SD) on these two items, respectively. During the 4 semesters following the implementation of these approaches, however, the scores for these two items rose to 4.7 and 4.2±0.2, respectively. It should be noted that the course instructor remained the same for all 6 evaluation periods.

Some of the positive/negative written comments provided by the students included:

"The feedback session was awesome because it helped some people realize that they're not as bad at public speaking as they thought!"

"Very helpful with public speaking techniques and making scientific presentations."

"Presenting and seeing the video tape of myself/meeting with the professor one on one was most beneficial to me."

"Viewing the taped presentation I gave helped to improve my performance."

"One suggestion I have is to have more big presentations rather than smaller ones."

"Peer reviews (flashcards) were helpful."

"Make the summary presentation like an actual interview session."

"The lab work has been really good for my resume."

Our alumni survey for this publication includes students who graduated with their baccalaureate in Bioengineering between 2000-2004. The data from this survey shows that students ranked our internship experience as "high" in terms of being important in preparing them to meet their career goals. Students scored the course a resounding 4.6/5 in response to the question, "how well did the course prepare them for their post-graduate careers."

These data suggest that our Intramural Research Internship is truly seen by the students as one of the highlights of our undergraduate program. Clearly, our Department of Bioengineering capitalizes on its proximity and decades-long very close relationship with the University of Pittsburgh School of Medicine and University of Pittsburgh Medical Center (UPMC); and most importantly, this course benefits from the commitment of our 17 primary and more than 100 faculty who hold secondary appointments in our Department and who continually welcome our undergraduate students into their laboratories. All of this is necessary to provide research experiences that our undergraduates clearly value as beneficial to their professional careers. This

validates our hypothesis that this course, as an extension of traditional classroom education, provides a unique opportunity for students to apply engineering principles and concepts taught in the classroom to real world situations. We feel this is a necessary experience for any student considering a career in bioengineering or medicine. Accordingly, we will continue to require this course for all undergraduates as part of our curriculum.

Appendix 1- Application for Registration

University of Pittsburgh
Bioengineering Mentorship/Internship Office
Savio L-Y. Woo, Ph.D. - Chairman Mentorships and Internships
Steven D. Abramowitch, Ph.D.- Course Instructor

Intramural Internship Application – BIOE 1002

Approved by:_____ **Date:**_____

Student Information

Last Name | First Name | Middle Initial | Pitt ID#

Address | City | State | Zip Code

Phone | E-mail

Faculty Sponsor Information

Last Name | First Name | Middle Initial

Title | Phone | E-mail

Department, School

Campus Address

Project Information

Project Title

Project Semester | Hours/week (minimum of 9 hrs/week) | BIOE 1002 Semester (same as project if Fall or Spring)

- **ON A SEPARATE PAGE, WRITE A 300-WORD DESCRIPTION OF THE WORK TO BE ACCOMPLISHED DURING THE INTERNSHIP.**

I ATTEST THAT ALL INFORMATION SUBMITTED ON THIS APPLICATION IS ACCURATE.

Student Signature | Date

Faculty Sponsor Signature | Date

SEND or FAX COMPLETED APPLICATION TO:

Steve Abramowitch, Ph.D.
BioE1002 Instructor
733 Benedum Hall
Pittsburgh, PA 15261
(412) 383-9618
Fax- (412) 648-2001
sdast9@pitt.edu

Appendix 2- Presentation Evaluation Sheet

University of Pittsburgh
Bioengineering Mentorship/Internship Office
Savio L-Y. Woo, Ph.D. - Vice Chairman for Research, Mentorships, and Internships
Steven D. Abramowitch, Ph.D.- Internship Program Director

BioE 1002 Symposium
Presentation Evaluation Sheet

Date _____

PROJECT TITLE: _____

_____

STUDENT/ADVISOR: _____

		SCORE
Introduction and specification of project goals	_____	/10
Content of presentation (overall)	_____	/20
Organization of presentation (overall)	_____	/20
Response to questions	_____	/20
Quality and effectiveness of visual aids	_____	/15
Delivery and effectiveness of speakers	_____	/15

General Comments:

Appendix 3- Faculty Mentor Evaluation Sheet

University of Pittsburgh
Bioengineering Mentorship/Internship Office
Savio L-Y. Woo, Ph.D. - Vice Chairman for Research, Mentorships, and Internships
Steven D. Abramowitch, Ph.D.- Internship Program Director

BioE 1002 Symposium
Faculty Sponsor Evaluation Sheet

Date _____

PROJECT TITLE: _____

_____

STUDENT: _____

		SCORE
Communication and Relationship Skills	_____	/15
Gained Knowledge, Training, Experience	_____	/15
Analytical and Judgment Skills	_____	/15
Planning and Organizational Skills	_____	/15
Experimental/Design Skills	_____	/15
Overall Effort	_____	/25

General Comments:

I ATTEST THAT ALL INFORMATION SUBMITTED ON THIS APPLICATION IS ACCURATE.

_____