OUT ON A LIMB: TEACHING BIOMATERIALS TO NON-BIO-ENGINEERS

Biomaterials as a Design Course in a Traditional Mechanical Engineering Department

L.D.T. Topoleski
Department of Mechanical Engineering, UMBC, Baltimore, MD 21250

Introduction: Biomaterials is somewhat of a novelty for the students in Mechanical Engineering (ME) at UMBC. During the delivery of traditional ME courses, faculty engaged in biomaterials (2 professors) or biomechanical engineering research (6 professors), use their research problems as examples to motivate students to take full biomechanical engineering classes (bio-materials, solid-mechanics, fluid-mechanics, and heat transfer). Students who enroll in the Biomaterials course are traditional ME students who have little or no background in bioengineering but have their curiosity aroused by the novelty of biomechanical engineering. Design content, especially in senior elective courses, is essential for ABET accreditation, and our students are required to take a required number of elective courses specified as "design." The author was asked to offer the Biomaterials senior elective as a design course. This paper focuses on an experimental format for a final project for the Biomaterials class at UMBC.

Methods: The enrollment for the Biomaterials class varies, but in the Spring of 2004, there was a smaller-than-usual enrollment (4 graduate, 4 undergraduate students). Two of the graduate students were involved in biomaterials research for their thesis, but both were in only their 2nd semester of study and only one had a bioengineering undergraduate degree. Students had only one undergraduate, introductory, materials science class, and an inconsistent background in basic biology. Therefore, the scientific/engineering content of the class focused on the "materials" rather than the "bio" aspect of biomaterials. Regular class lectures were taught through a combination of advance materials science concepts, case studies incorporating "just-in-time" learning modules, and examination bodies of work (4-5 sequential papers by the author's colleagues), to show the students the progress of scientific inquiry.

Because of the relatively small class size, The Class was set up as a fictitious consulting company for the final project; that is, the entire Class constituted the "group" for a final group project. The problem statement (verbatim) was:

Ms. Siouxsie L'Mizz ("Mizzy" to her friends), has had a difficult go of it recently. As they say, it never rains but it pours. Over the past 2-3 years, some severe and some not-so-severe medical issues have occurred, as listed below.

As recent hires of the Dr. T's Magic Dragon Oil Elixir Co. ("Biomaterials with a smile, our specialty!"), we have been retained as consultants to Ms. L'Mizz and the battery of physicians working to improve her quality of life. It will be our task to prioritize management of medical treatments, research current state-of-the-art/science treatments and interventions, and improve medical treatments using our design backgrounds and knowledge of mechanics and biomaterials. Medical issues: 1. Cataracts in both eyes, right eye tolerable, left eye has difficulty seeing, 2. Diabetes, hates needles, would like to reduce or eliminate injections, 3. Elective mastectomy (bi-lateral). Grandmother and mother died of breast cancer, recent biopsy revealed possible pre-cancerous cells. <u>Severely upset</u> because of physical changes, 4. Arthritic left knee, difficult to walk (right knee OK); arthritic right hip, difficult to walk, 5. Occasionally forgets why she entered a room, 6. 54% stenosis in the coronary artery, 7. Calcification and loss of function in the tricuspid and mitral valves in the heart, 8. 62% stenosis of the bifurcation of the aorta into the common iliac arteries, 9. 75% stenosis of the right renal artery, 10. 82% stenosis of the ureters, 11. Lost all molars on both the upper and lower left jaw, 12. Shin splints in both legs, 13. Severe right ulnar fracture one year ago. Fracture has never really healed, and because of the type of fracture, the right forearm is 17.6 mm shorter than the left.

The deliverables were (verbatim):

<u>For the Class as a Design Team:</u> *1) A justification of the chosen topics (why were these problems chosen? why are they important/priorities?); 2) A Cost Analysis of the treatment package; 3) The proposed treatment strategy; 4) What will be required for FDA approval for the proposed devices; 5) Prognosis for the client after the designs are implemented*

<u>For each Group:</u> *1) Description of the disease or condition (summarize the cause(s), symptoms, and potential treatments); 2) A description of the currently available treatments ("standard" treatments at, e.g., a local or community hospital, State of the Art treatments at a research hospital (e.g., Johns Hopkins, U. Maryland), differences between "conservative" and more invasive treatments; 3) A research evaluation of the "state of the science" in treating the condition; that is, what are researchers working on that appears to be promising; 4) A new design of a device to treat the condition, incorporating the "state of the science" described above (what is the improvement over the current treatment?, design rationale, feasibility of the design (not of the potential effectiveness of using it as a treatment), information lacking to bring the design into practice); 5) Cost of manufacturing;* <u>Second</u>**,** *we need a company logo (extra credit points)*

Results & Discussion: The students were given several models of approach, including working together with a management structure or dividing into smaller units. The students divided themselves into smaller groups to focus on specific ailments. To their credit, the students chose to investigate biomaterials applications for Ms. L'Mizz's cataracts (intraocular lenses), arterial stenosis (drug-eluting, surface modified stents), urethral stenosis (bioresorbable stents) and arthritis (artificial joints), rather than, say, treatment of shin splints. The final project was well presented, and consisted of sub-sections based on the treatment chosen by the particular sub-group of students. The write-up was based predominantly on background research, and was notably lacking in original design content. I believe that this is because of the students' backgrounds, more specifically their lack of materials science, basic biology, and biomaterials background. One positive interpretation of the students' final product was that, because they had little prior experience in biomaterials, they were fascinated by the subject matter and concentrated on expanding their background.

The students enrolled in the course were used to more quantitative course material. Although I encouraged them to perform quantitative analyses for their contribution to the project, their materials and biomaterials background was limited. Important and current biomaterials research areas, such as surface analysis, drug delivery, and tissue engineering, were largely delivered as descriptive, rather than quantitative, subjects. It was clear from one or two introductory lectures that the students lacked, for example, the fundamental biology background to study tissue engineering in any depth. Since the lectures were, by necessity, delivered with descriptive content, the students may have assumed that the professor was interested in descriptive content for the final project.

The results discussed here are largely anecdotal. Our Department has recently led the initiative in Engineering Education at UMBC, and we believe that there will be opportunities to perform more quantitative educational research in the future. The concept of "The Class as the Group" for a group project may motivate students' efforts, since the final submission requires input from each student in the class. Finally, it is important to note that biomaterials can be an exciting and challenging subject for students of almost any background, and the instructor has the charge to tailor their expectations to the students' backgrounds.