A Model for Curriculum Evaluation and Revision in Bioengineering

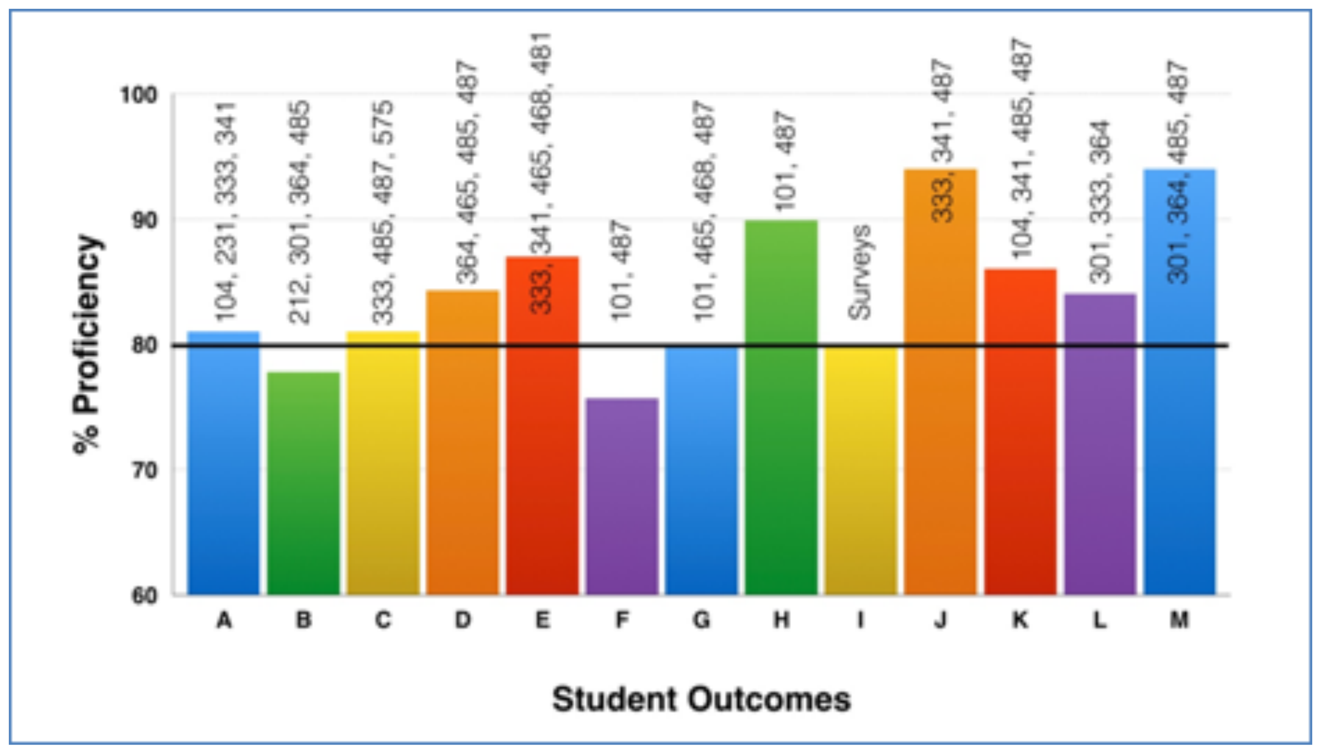
Pun To (Douglas) Yung
Department of Biomedical and Chemical Engineering, Syracuse University, NY 13210

Abstract

Curriculum evaluation and revision are often driven by student comments and satisfaction, but they may not reflect the attainment of **learning outcomes**, impact on educational objectives or long-term knowledge retainment. This poster uses a number of direct and indirect assessment on student learning outcomes to holistically revamp individual courses and as a **yardstick for curriculum evaluation and revision**. Assessment plays an integral role in shaping behavior and values. Some of the assessment strategies include course-based assessment activities, closing the feedback loop, developing course portfolios, and connecting the gaps between formative and summative evaluations.

Current Assessment Method

The Accreditation Board for Engineering and Technology (ABET) stipulates the following Student Outcomes, which are measured by assessing student performance in certain courses. The figure shows the aggregate program-wide assessment results in 2017-18. The expected level of attainment for each Student Outcome is set at 80%. This threshold was set after an initial review of assessment data and based on a consensus of the faculty.



A An ability to apply knowledge of mathematics, science, and engineering

B An ability to design and conduct experiments, as well as to analyze and interpret data

C An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

D An ability to function on multidisciplinary teams

E An ability to identify, formulate, and solve engineering problems

F An understanding of professional and ethical responsibility

G An ability to communicate effectively

H The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

I A recognition of the need for, and an ability to engage in life-long learning

J A knowledge of contemporary issues

K An ability to use the techniques, skills, and modern engineering tools necessary for engineering practic

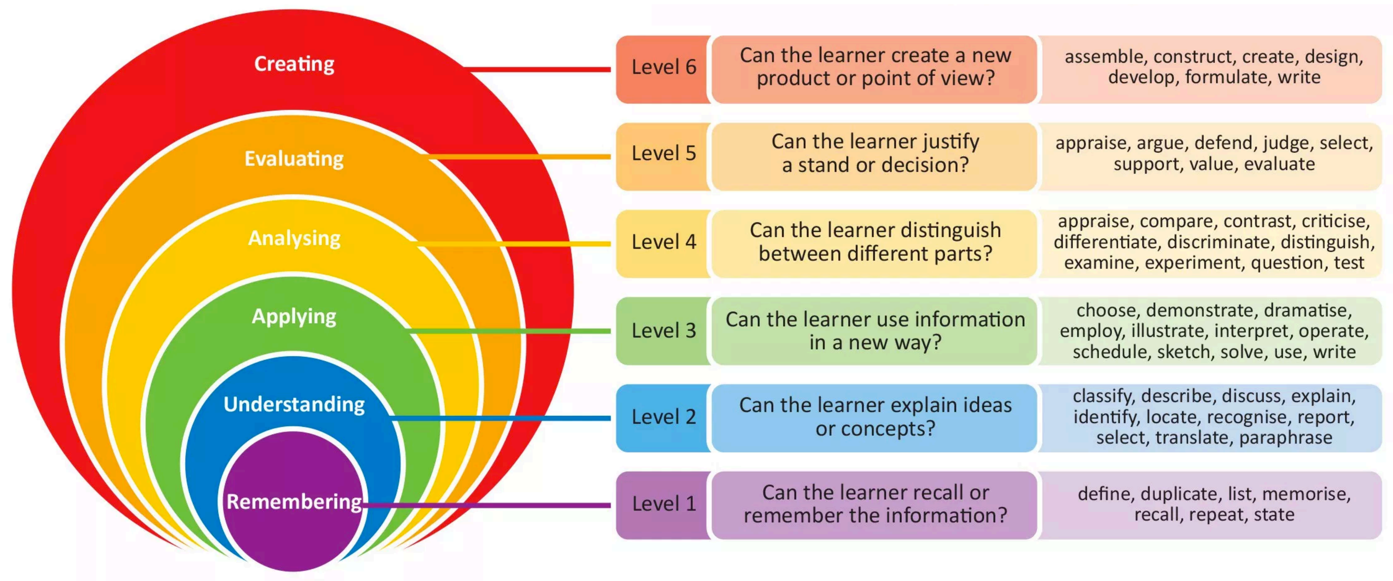
L An understanding of biology and physiology, and the capability to apply advanced mathematics, science, and engineering to solve the problems at the interface of engineering and biology

M The ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems

Proposed Evaluation Plan

Bioengineering is a diverse multidisciplinary field that often presents challenges for striking a balance between the breadth and depth. While the current assessment methods suggest a general attainment of learning outcomes, it is deemed important to place more emphasis on specific senior courses where more summative assessments take place. In BEN 485 (Senior Lab) and BEN 487 (Senior Capstone Design), students are found to be generally weak in creating, evaluating and analyzing knowledge, all top levels in the Bloom's Taxonomy.

Finite element analysis (FEA) and **computed aided design (CAD)** are then added in the curriculum following a **spiral curriculum** approach. Spiral curriculum sims to introduce the same topic throughout the entire 4 years of college, with each encounter increasing in complexity and reinforcing previous learning. This change is expected to shift the predominantly mathematical approach in biomedical engineering curriculum to a more **constructivist and concept-based pedagogy**. At Syracuse University, **Autodesk Inventor** and **COMSOL Multiphysics** are introduced and reinforced with required courses along the 4-year curriculum. Both **formative and summative assessment** are used.



Computer-Aided Design

Freshman ECS 104
INTRO TO CAD
2D sketch, 3D modeling, in a freshman programming class

Sophomore BEN 231
MORE ON CAD
Intermediate concepts & techniques in CAD, 3D printing project in a sophomore BME fundamentals course

Junior BEN 364/385
ADVANCED CAD
Bio-BAD, prosthetics, rapid prototyping, computer-assisted surgery, radiation phantom in junior lab

Senior BEN 485/487
CAD APPLICATIONS
Design & fabrication of structures for capstone design; integration with FEA in senior lab and capstone design

Finite Element Analysis

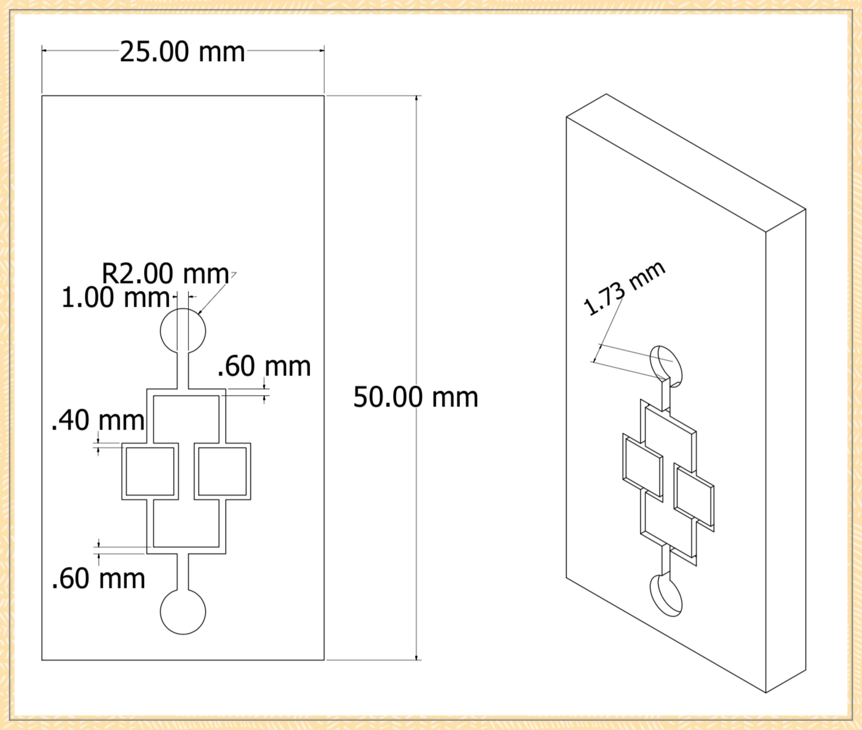
Sophomore BEN 231
INTRO TO COMSOL
Intro to FEA and simple Comsol analysis techniques in a sophomore BEN fundamentAL course

Junior BEN 341
COMSOL MODULES
Fluid flow, mass transfer and heat transfer modules in a junior heat & mass transfer course

Junior BEN 364/385
COMSOL MODULES
Structural mechanics, electromagnetic modules in junior lab

Senior BEN 485/487
FEA APPLICATIONS
Integration of Comsol and CAD; use of Comsol in design and model in senior lab and capstone design

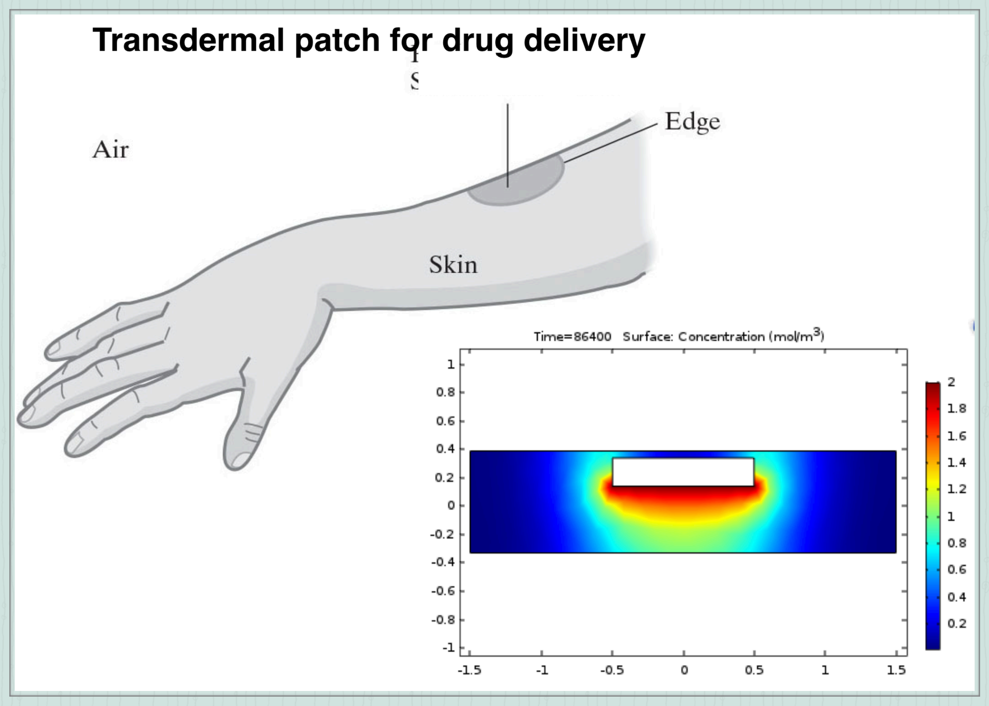
BME Junior Lab Quantitative physiology



3D-printed Microvasculature

The intricate meshwork of blood vessels twists and turns inside our bodies, delivering essential nutrients and disposing of hazardous waste. There are lots of research endeavors to re-create artificial blood vessels from scratch. Students use Autodesk Inventor to **create a simple blood vessel branching pattern and have it 3D printed** in the student machine shop.

Junior Course Heat and Mass Transfer



Drug delivery through a patch

Concentration of drug should remain constant within the therapeutic window while requiring minimal administration in order to achieve the desired treatment efficacy. Implantable polymer has been studied extensively over the last few decades to achieve extended therapeutic concentrations of drugs. Students **design a patch to achieve best drug delivery efficiency and bioavailability by optimizing patch dimensions, geometry, implant location, diffusivity, and other mass transfer parameters.**

Capstone Design Evaluation

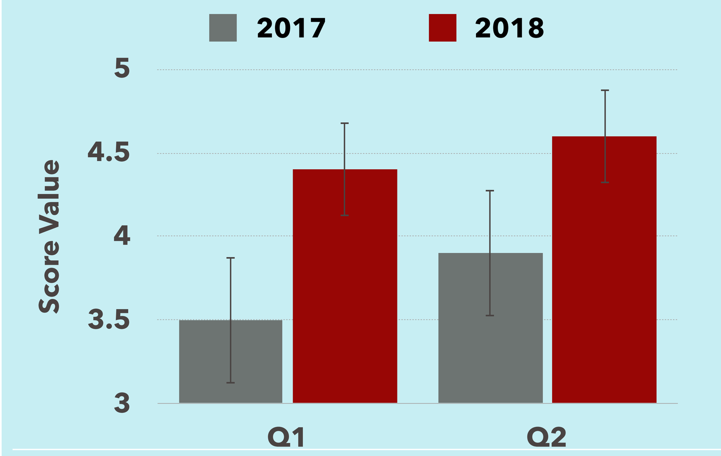
2017 (n = 44) students not exposed to this sequence of software

2018 (n = 38) students were exposed to this sequence of software

Q1. Use techniques, skills, and modern engineering tools, necessary for engineering practice

Q2. Design a system, component, or process to meet desired needs

(5 = most, 1 = least)



Assessment on Active Learning

Project evaluation is based on the Kirkpatrick's model, with learning outcomes conceptualized at four levels. **Reaction** is assessed by perception surveys from students, faculty and clients. **Learning** is assessed by the knowledge, attitudes and skills gained. **Behavior** will be assessed by post-graduation surveys of alumni and surveys on employers on research attitudes, skills and productivity. **Results** will be assessed by longitudinal studies on career tracking and career success.

BME Senior Lab Senior Capstone Design

3D-printed Prosthetic Socket

The proposed problem requires a new design of a prosthetic socket for a transradial amputee. Currently, there are many options available for lower limb prosthetics, but not as many for upper limb prosthetics. Issue arises when the terminal device is attached to the prosthetics socket.

Each patient that requires a prosthetic first needs to have measurements of their residual limb taken. This occurs during the first visit to the volunteer site. This current process involves transportation that not all patients have access to. To improve this process, **the ideal socket needs to be designed so that it can be pre-fabricated and adjustable to fit each specific patient's residual limb dimensions on site.**