Integrating Engineering Design throughout the BME Curriculum

Innovation in Curriculum

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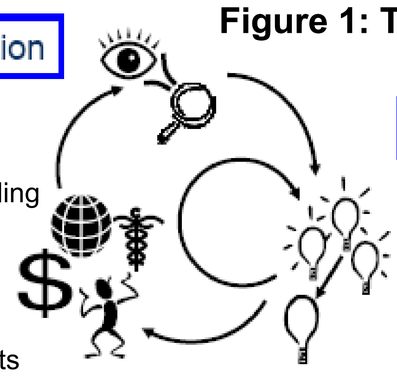
PROBLEM: Engineering design is difficult for students when first introduced at the senior level

For the development of our senior capstone design course, we conducted extensive nation-wide benchmarking. In consultation with learning scientists, a program was initiated where each 3-4 person student team received a sponsored project. Each project has an external industry, government or clinical sponsor. Student teams work on the project for the two-semester design sequence. Sponsors for BME design include: NASA, UT MD Anderson Cancer Center, International Biomedical, Inc., and the Central American Outreach, a non-profit.

We have recently been re-evaluating our undergraduate curriculum and a recurring theme is a need to integrate engineering design throughout the educational process. This work has begun at either end of our course curriculum with a 2-semester senior capstone design course (taught since 2005) as well as a one-hour freshman design course (taught since 2010). Both courses have both lecture hours and laboratory time. We also have two, semester-long junior labs (taught since 2004) that have some open-ended, team-based design elements. Our experience along with engineering education research suggests that early introduction to problem-based learning, the iterative nature of the design process (Figure 1), and the skills to tackle open-ended problems would benefit student learning and improve the quality of learning outcomes.

Figure 1: The Design Life Cycle

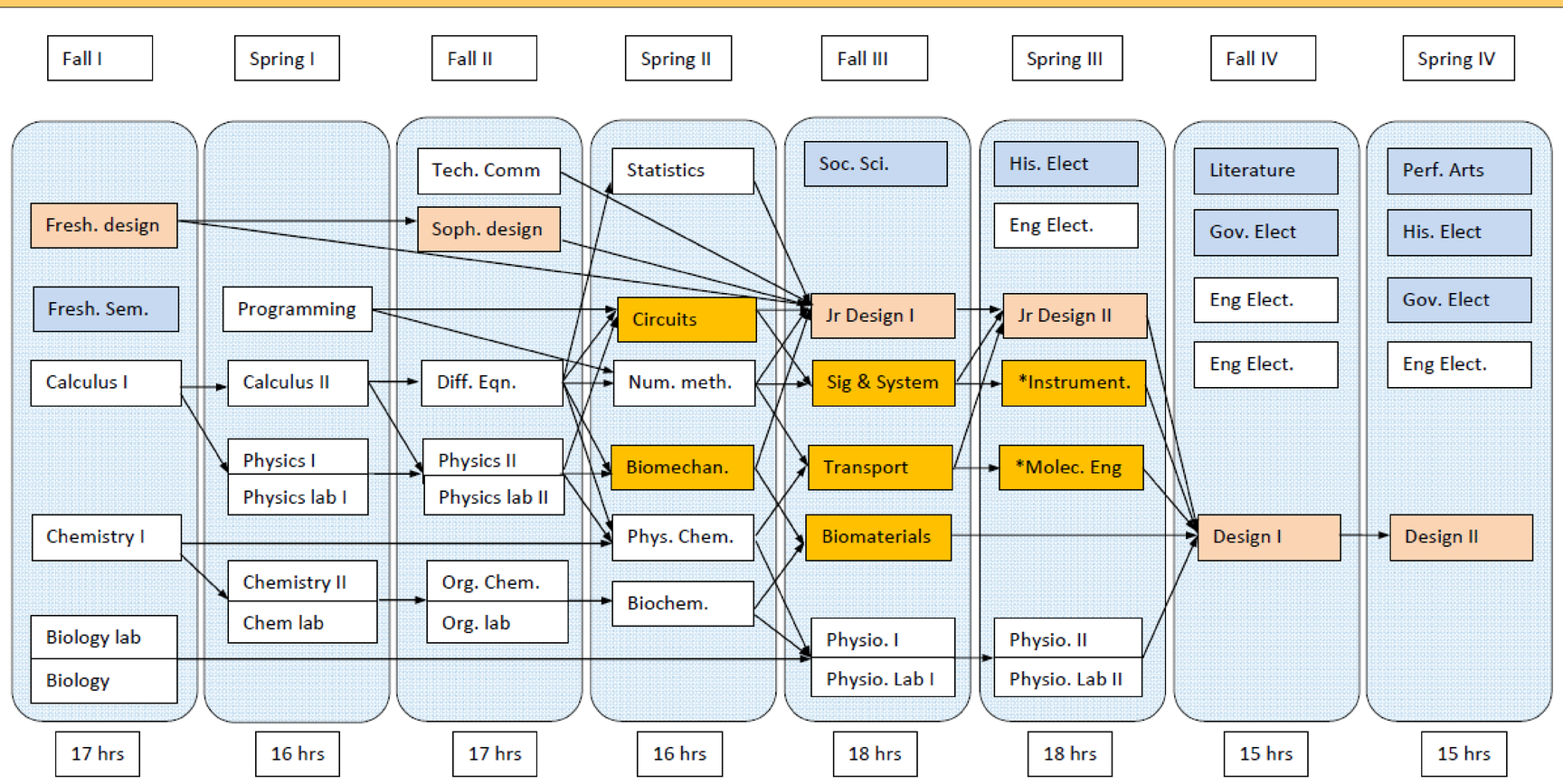
1. Problem Definition
- Team Building
- Team Competencies
- Planning and Scheduling
- Mission Statement
- Needs Assessment
- Functional Modeling
- Reverse Engineering
- Benchmarking/ Patents
- Quality Function Deployment
- Design Specifications



2. Concept Generation
- Intuitive CG Methods
- Directed CG Methods
- TRIZ
- TRIZ Software
- Concept Selection
- Estimation
- Analysis & Iteration

3. Solution Implementation
- Design Embodiment/ Form
- Product Documentation
- Device Categorization and Testing
- FDA/Regulations

SOLUTION: Introduce Design at all Levels across the Curriculum



Educational Objectives

The goals for this learning innovation are to develop a roadmap for changing how we teach engineering design in the Biomedical Engineering Department at the University of Texas. It must be appreciated that major curriculum reform does not necessarily occur en bloc, but frequently must occur through a number of staged transitions. I am interested in questions such as,

"How do we integrate design courses with existing core classes such as biotransport and biomechanics?"

"How do we ensure that there is consistency across the design classes with different instructors?" and

"How do we ensure that the problems and labs assigned remain fresh across multiple classes of students?"

Curriculum Execution

The proposed innovation centers around the revision and integration of our curriculum. We intend to execute this change through a series of staged transitions.

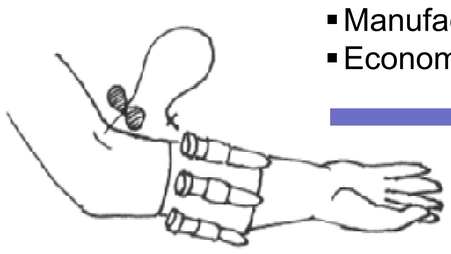
Step 1: Introduce a freshman design course to complement the senior design course. (complete)
Step 2: Introduce a sophomore design course.
Step 3: Transition the existing junior labs to an engineering design methodology rather than the current proscribed laboratory format.
Step 4: Integrate the design courses with existing core classes.

This design integration will be made possible through the recent hire at UT Austin of a laboratory coordinator with oversight of all the laboratory courses. This individual will provide educational goals, direction and course content.

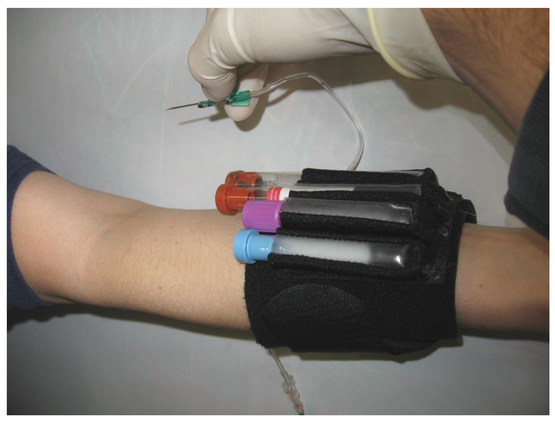
Learning Activities

Biomedical design is problem-based, open-ended and iterative.

Example: Process of transferring a concept sketch into refined geometry and material choices



- Geometry
- Material
- Manufacturability
- Economics



Educational Assessments

We have engaged learning scientists to study the efficacy of the learning process in the design sequence.[1] Students were given assessments at various times during the year. Preliminary data suggests a trend of students orienting to more of a design focus, meaning that over the semester, their designs included more information about how the design would be constructed, schematic views, and more attention to the "voice of the customer."

1. Martin, T., S. Rivale, et al. (2007). Annals of Biomedical Engineering 35(8): 1312-1323.