SCAFFOLDING AND ASSESSING ENGINEERING DESIGN: EFFECTING PROGRAM CHANGE FROM COURSE INNOVATIONS

Molecular Biosciences and Bioengineering

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Department/Program Facts

- Number of faculty 5
- Number of students 45
- Number of graduates every year 7
- Established program accredited by ABET

Introduction

The Biological Engineering program sought to improve student performance during program level assessment, specifically in the application of the engineering design process. Most recently, 59%, 50%, and 33% of students were meeting 3rd year target levels midway through the year.

Our approach was to implement parallel class and individual design projects at the junior level that would provide both a way for students to learn together in a guided exercise and to apply learned concepts to a project of their choosing. The resulting student work, assessment, and insights gained were used to scaffold assignments and content in courses throughout the curriculum.

2018-19 Assessment Results

1. **77%** meeting 3rd year targets for **identifying** complex engineering problems. [i]
2. **77%** meeting 3rd year targets for **formulating** complex engineering problems. [ii]
3. **55%** meeting 3rd year targets for **solving** complex engineering problems. [iii. Iv]

Rubric Development

- Use actual student work to help reach consensus on rubric language.
- Focus on development and ability of a student progressing through the curriculum rather than deficit.

Faculty Insights

- Create more effective assignments that specifically support achievement.
- Improve communication of expectations and outcomes
- Vertically integrate a design project throughout curriculum in parallel with student course work on design.

Student Insights

- Engineering design is a new experience.
- Peer feedback very helpful.
- Allocate class time for interactions.
- Allow student the iterative process for project revision.

Successful Strategies

- Engage faculty in conversations about expectations for learning
- Use rubric as a catalyst to reflect on teaching and student development

SCAFFOLDING PLAN WITH VERTICALLY INTEGRATED PROJECT

BE 260
Challenge students to **identify** specific ways engineering can address problems facing society.

INTRO
Carotenoid production in yeast. Problem exploration.

BE 350
Identify, **formulate**, and **solve** an engineering problem in an open-ended project of student's choosing.

CHALLENGE 1
Design a system to extract carotenoids

BE 350L
Formulate and **solve** the design of a temperature control system for yeast growth.

CHALLENGE 2
Implemented as primary course project.

BE 420
Identify, **formulate**, **solve**, fabricate, and test a sensor or instrument.

CHALLENGE 3
Design a sensor to determine carotenoid levels through color measurement.

BE 437
Use simulation software to **solve** an engineering problem and refine solution.

CHALLENGE 4
Design a scaled-up system to produce carotenoids in large quantities.

BE 460
Experimental acquisition of parameters required to **solve** the problem of suppliying the oxygen required for yeast growth.

CHALLENGE 5
Implemented as primary course project.

LEADING TO SUCCESSSFUL CAPSTONE PROJECT

Student Learning Outcome 1 Rubric

Students will have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics.

Indicator	Incoming	2nd Year	3rd Year	4th Year
i. Identifies the engineering problem within the overall problem or context.	Identifies a problem of importance. **Broadly** suggests that engineering can help solve the problem.	Explains with **some** detail how engineering can address the **overall** problem.	Explains with **adequate** detail how engineering can address **a specific** task, function, or capability.	Explains **exactly** how engineering can address **multiple specific** tasks, functions, or capabilities to address the overall problem.
ii. Specifies the requirements that the solution must meet.	**Qualitatively** describes a requirement or goal of the solution. Relies on prior or common knowledge to identify requirements.	**Adequately quantifies** at least one requirement. Incorporates important considerations such as function, standards, constraints, and client input.	Evaluates the **more important** considerations to **quantify** the requirements.	Evaluates **all** relevant considerations to **quantify well-specified** requirements.
iii. Applies scientific and engineering methods to solve the problem.	**Conceptualizes** the underlying mechanism of a solution.	Applies math, science, and engineering to develop a solution that meets **some** specified requirements. Solution may include **some** errors.	Applies math, science, and engineering to develop a solution that meets **all** specified requirements. Solution may include **minor** errors.	Systematically and consistently applies math, science, and engineering to develop a **rigorous** solution that meets the all requirements and is essentially **error-free**.
iv. Evaluates and refines the effectiveness of the solution.	**Theorizes** the feasibility of a solution.	**Evaluates** the outcome and **describes** how the solution **can** be improved.	**Evaluates** the outcome and **refines** the solution to improve the final outcome.	**Thoroughly** evaluates the outcome and refines the solution to achieve the most **feasible** outcome.

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