Work-In-Progress –Joint Senior and First-Year Student Design Projects for Student Retention

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Abstract **- Many programs fail to tie concepts covered in fundamental mathematics and science courses with the application of these concepts to engineering fields; this disconnect increases the difficulty of retaining first-year engineering students. Design projects are one method to increase student understanding of the connection between these courses and engineering, but first-year students lack the necessary skills and knowledge to participate in many projects. This fall, we will began a pilot project that allows first-year students enrolled in the *Introduction to Chemical Engineering* course to work as project interns on senior chemical engineering student design teams. The senior design laboratory focuses on product design; and the seniors provide training, mentoring, and feedback to their assigned interns. The first-year and senior students meet in class weekly to discuss the project. The senior project consists of four phases: (1) initial product concept development, (2) product selections, (3) process design, and (4) final conceptual design and testing. Through this design project, we anticipate the first-year students will increase their understanding of the field of chemical engineering, the practical application of their coursework, and begin developing teamwork and oral and written communication skills.**

Index Terms – capstone, collaboration, design, project.

INTRODUCTION

One method to introduce students to the practice of engineering is to engage the students in design projects. Design work allows the students to identify a need to be satisfied, define the need in terms of requirements, create potential solutions, assess the solutions in terms of the requirements, and select the best solution. Creating and assessing potential solutions also provides the opportunity to apply the mathematics, science, and engineering methodologies that the students have learned. Exposing students to engineering practice and providing applications for the subject matter they are studying are benefits of providing design experiences throughout the curriculum. These benefits are motivating an increasing number of engineering programs to introduce design projects for first year students. However, a concern is that first-year students have a limited knowledge base, which can limit the types of projects that can be considered. The students may have limited or no prior experience with open-ended projects and may feel overwhelmed by the number of options and amount of work involved.

We have developed a process to team senior and first-year students as a means of overcoming these limitations. The seniors provide project guidance and demonstrate a deeper technical knowledge base to utilize in the design task. The first-year students are capable of generating ideas, conducting research, and developing product requirements. The senior students benefit from the development of their leadership and project management skills by practicing delegation of certain tasks to first-year students. In turn, the first-year students learn from the senior students and have the opportunity to work on a more comprehensive project than would be possible otherwise. This paper discusses plans for the implementation of this joint project.

The idea of having first-year and senior students collaborating on projects is not new. In most of these collaborations the seniors are assigned to be mentors or technical experts for the first-year course projects [1]-[3]. Another option is to involve the first-year students with the senior-level capstone projects by having them serve as interns, working on tasks provided by the seniors [4]. Our approach is similar to the internship model except that the first-year students also have specific assignments for the *Introduction to Chemical Engineering* course related to the capstone course; the specific details of these tasks will be assigned by the seniors with approval from the instructors.

JOINT COURSES

The *Introduction to Chemical Engineering* course was added to the curriculum almost eleven years ago to give students an overview of the field and provide hands-on applications of the first-semester chemistry and mathematics courses. The course focuses on fundamental engineering concepts, chemical engineering applications, teamwork, problem solving, and the engineering design process. From the initial offering, this course included a design project, such as, the conceptual design of a facility to make a food or beverage product of the students' choosing, a device to filter water, a kidney dialysis module, and a vehicle powered by a chemical reaction. The projects required students to solve an open-ended problem by creating several possible solutions, assessing these solutions with respect to specific criteria, and performing some rudimentary quantitative analysis. However, the course instructors have always been mindful of not requiring a project beyond the capabilities of the first-semester students. To give the first-year students the

opportunity to work on a more complex problem, the authors developed a proposal to have the first-year students work as interns on a senior design project.

To accomplish the joint project, students from the first-year course will be paired with seniors in a capstone design course. The third course in a sequence of four, the capstone design course focuses on product design and builds on skills developed in the first two design courses: economic analysis, flowsheet development, equipment design and process simulation. The senior students receive instruction in basic project management [5]-[6], process for product design [7]-[9], and methodologies for establishing design specifications [10]. Each senior team will be paired with one to two teams of three first-year students. The first-year students will meet weekly for three hours, with the first half of the meeting time dedicated to fundamental engineering concepts. The second half of the meeting time will overlap with the senior design course to facilitate communication between the two student groups. In addition to team meetings, the joint class times will be used to cover material on team work, project management, product selection factors and market analysis.

The first joint class meeting will be used to introduce the project and initialize teams selected by the instructors before the courses begin. Information on team management and communication styles will be given to both senior and first-year students. As their first assignment, each first-year team will decide on a team working style, how to resolve team differences, and methods for communication within the team. They will also work with their assigned senior team to establish out-of-class meeting times and penalties for team members missing deadlines and meetings. Teams will be expected to meet weekly with more frequent electronic communications, and first-year students will keep a record of team communications. Both groups will submit biweekly memos to keep instructors informed on project progress.

PROJECT DESIGN

The project requires students to develop a new consumer product and production facility. The ultimate goal of the project is to produce a design package that includes a proposed product with specifications, a design for a production facility, an economic analysis of the proposal including demand projections, and an assessment of environmental and societal impact of the project from raw materials to finished and packaged product. For the purpose of assessment for the interns, the project will be divided into four phases each with a number of assignments as summarized in Table I. The overall assignment guidelines for the interns will be set by the *Introduction to Chemical Engineering* instructor but the specific research topics and performance factors will be decided by the senior teams.

TABLE I
PROJECT PHASES AND FIRST-YEAR ASSIGNMENTS

Phase	Assignments
1. Initial Product Concept	1. Product market research 2. Initial product list
2. Product Selection	1.Product Analysis 2. Product Sales Pitch
3. Process Design	1. Analysis of a similar product
4. Final Conceptual Design	1. Economic, safety, and social impact analysis

I. Phase 1

In the first phase, both first-year and senior students will research and identify product opportunities in a market based on social, economic, and technological trends. The first-year students will receive information on appropriate research and joint class time will be used to give both groups tools for assessing market requirements [11]. Additional training and information will be given to the seniors and they will be expected to guide the first-year students in the initial research. The first-year students will produce a project opportunities report and work with the seniors to brainstorm an initial list of projects. Together, the multi-level teams will be expected to produce a list of at least twenty potential products.

II. Phase 2

In the second phase, the first-year students will develop a product selection matrix based on the trends identified in phase 1 as well as equipment costs and manufacturing issues identified by the seniors. The goal is to narrow down the potential products to fewer than six. The first two phases will require extensive collaboration and frequent communication between the seniors and interns, with the seniors providing feedback and increasing amounts of technical expertise. Working with the seniors, the students will refine the product selection matrix and assign weights to each of the performance requirements. During this period, the first-year students will be learning about visual presentations. For the final portion of phase two, the first-year students select their top three products and create a sales pitch highlighting their top product choice. The seniors will have the final say in product selection and will provide their analysis of the chosen product to their interns.

III. Phase 3

In the third phase, the seniors will create a process to produce the desired product and design a production facility. During the semester, the first-year students will learn about physical properties, types of energy, flow charts, and rudimentary material balances. The first-year interns will use these fundamental engineering to analyze a product similar to the one chosen in the second phase. The interns will spend much of this phase in the laboratory conducting hands on experiments. They will also work to produce a simplified process flow chart for the desired process. The seniors will work with the interns to explain the overall design process,

and the first-year students will individually research a piece of equipment used in the design process and explain its use to the team.

IV. Phase 4

In the fourth phase of the project, the teams will work together to produce a final project package, including a safety review, environment impact analysis, and analysis of social impacts. Each first-year intern will be responsible for becoming an expert on one of these components and educate other team members regarding their portion of the project. The senior students will be responsible for incorporating these components into the overall package.

ASSESSMENT

To assess the impact of the joint design project, we will use a variety of assessment methods. Rubrics used in all departmental courses for oral presentations and written reports will be used to evaluate first-year presentations and reports. In-class quizzes and homework will be used to assess student understanding of fundamental engineering concepts before and after they are used in the project. Post surveys will be used to evaluate the students' opinions of the project and their perception of their increase of knowledge in the field of engineering.

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