Abstract

Northeastern University requires all first year engineering students to take the engineering design course and a computational problem solving course. Resources are needed for designing, constructing, and testing projects for the design course, along with computers and additional electronic equipment that are required in the second computation course to reinforce the applications of engineering principles taught in class. The current available space does not adequately support project work for these two courses.

The objective of this project is to design a resource, or set of resources, that are versatile and modular enough to cover the needs of both courses, while maximizing space utilization on campus. Five different resources were developed to meet this objective, ranging in total cost and spatial footprint. The first and lowest cost resource design draws on the many upperclassmen engineering labs already on campus. The second design, still low in cost, is an upgrade of the current space to better support students. Higher in cost, the third design expands the footprint of the current space, while the fourth design adds state-of-the-art equipment and tooling for student use. Lastly, the fifth design brings the lab to the classroom in the case that no space can be dedicated to freshmen project work.
The Need for Project

Current resources allocated to freshmen do not adequately support their course work.

To build a solid engineering foundation, Northeastern University requires all first year engineering students to take the engineering design and computational problem solving courses. The design course is offered during the fall semester and teaches the design process using case studies for multiple engineering disciplines. Students develop original design solutions to a technical problem as a term project (Rep 6.1). The problem solving course is offered during the spring term and introduces students to engineering analysis and design using mathematical algorithms and high-level programming languages (Rep 6.2). Resources are needed for students to successfully design, construct, and test projects for these courses. A survey of the freshmen class and their professors indicated that the current resources available to students for project work are inadequate, with many negative responses concerning capacity, tooling, and general maintenance (Rep 71.). Therefore, a new resource or set of resources must be designed to meet the project needs of both students and professors, so professors can effectively teach and students can effectively learn basic engineering fundamentals.

The Design Project Objectives and Requirements

The objective of this design project is to design a resource that meets the project building needs of both students and professors.

**Design Objectives**

The objective of this project is to design a resource, or set of resources, that meets the needs of first year students and their professors in the engineering design and computational problem solving courses (Rep 4.1).

**Design Requirements**

Design alternatives must meet three minimum criteria for consideration (Rep 4.1). A design alternative must facilitate active learning so professors can reinforce the engineering principles taught during class. It must accommodate at least one standard class size of 30 with students working in groups of two to four, as capacity and wait time were consistent issues noted by students in the survey (Rep 7.1). Finally, the design must support current projects issued by first year professors, as well as future projects that reflect the different engineering disciplines offered at Northeastern.
Design Concepts Considered

Five different design alternatives were developed ranging in cost and spatial footprint, to best meet the needs of the students, professors, and the university. After considering the needs of the students, professors, the College of Engineering, and Northeastern University, five design concepts were developed ranging in cost and project timeline (Rep 10.1). Called “Right Now”, the first alternative design requires little to no start-up capital and seeks to use current resources available on campus to facilitate active learning, including upperclassmen labs and the current Engineering Project Zone. Next is the “Engineering Project Zone Upgrade”, which focuses only on the current space allotted to first year engineering project work. This alternative seeks to fix some of the inadequacies of the Zone while remaining reasonable in cost and project timeline. It may be possible to expand the Zone in its current location, so the “Richard’s Basement Expansion” alternative alters the current layout of the basement to optimize the utilization and versatility of the space there. This alternative is more costly and may require the breakdown or construction of walls, increasing the timeline to implement the design. In the case that a substantial amount of funding is available to finance a first year project lab, the “Dream Lab” alternative is, in part, a marketing tool to attract prospective students to Northeastern’s College of Engineering. It is built off of the Richard’s Basement Expansion alternative and is equipped with the latest in technology and tooling to support any and all varieties of engineering projects. Lastly, in the case that no space is designated or available for first year project work, the “Modular Lab” alternative brings the lab to students in the classroom. This alternative will be substantially less than most of the other alternatives in both cost and project timeline.

Of the five alternatives described, three were chosen for full development based on the results from a decision matrix shown below (Rep 10.2). The top three alternatives are the “Right Now”, “Richard’s Basement Expansion”, and the “Modular Lab” alternatives, as they best meet the design requirements detailed earlier. The current Engineering Project Zone cannot accommodate a full class size, so upgrading without expanding will not help. The “Dream Lab” piggy-backs on the Richard’s Basement Expansion alternative, so there is no need to develop it on its own.
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### Decision Matrix to Select Designs

**Recommended Design Concept**

**The lowest cost design**

- Three designs were chosen for full development; the lowest cost design that draws existing labs, the higher cost expansion of the current project space, and the modular design that brings the lab to the classroom.

**As mentioned above, three design alternatives were selected for full development. Each alternative is detailed below.**

1. **Right Now:**

   This design alternative is very low cost and can be implemented in a short period of time. It uses resources already on campus to facilitate active learning, drawing primarily on the many upperclassmen labs to give freshmen experiences in the different engineering disciplines available at Northeastern. Analytical investigations include scheduling all the first year engineering students lab time using an Operations Research assignment problem (Rep ?). The key advantages to this alternative are the low cost and immediate application. Current assets already located on campus will have higher utilization rates and first year students will get broader exposure to the engineering disciplines offered at Northeastern.

2. **Richard’s Basement Expansion:**

   The Richard’s Basement Expansion alternative seeks to enlarge the current Engineering Project Zone into a more adequate and accommodating space for student project work. Analytical Investigations include results from the Student/Professor survey, which revealed the need for a larger space with better tooling available (Rep 7.1 & 7.2). The key advantage to this alternative is the extra space it provides. Taking up multiple areas in the basement, there is more than enough room to accommodate one full class size and the different areas for designing, building, and testing projects...
spreads students out so they are not crowded.

3. Modular Lab:
The Modular Lab is designed so that the lab can be taken to students in a classroom if no space is officially designated for project work. It holds all materials necessary to complete a given project and these materials can range in cost, pending what funds are available. Analytical and experimental investigations include purchasing some kits that could be used as part of this lab, along with price comparisons of equipment and tooling. The key advantage of this alternative is that it is modular, not requiring a designated space for operation. Its components can also range in cost, pending what funds are available to purchase materials and ready-to-order kits.

Financial Issues
Financial issues vary by design, but the most significant cost is associated with construction at approximately $200/sq ft. Financial issues vary between design alternatives. For the Right Now alternative, there is little concern about cost. The only financial issues foreseen at this time are related to lab operating costs and materials costs that are probably not significant. For the Richard’s Basement Expansion alternative, issues include construction costs, equipment and furniture costs, and staffing and operating costs. Construction costs alone are estimated at $200/sq ft. The only financial issue for the Modular Lab is the cost of the unit and its supplies, which can vary based on amount of funds available.

Recommended Improvements
A state-of-the-art Dream Lab is the next iteration in developing this type of lab space. As an improvement to the Richard’s Basement Expansion alternative, the Dream Lab provides state-of-the-art tooling and equipment for first year students to design, construct, and test projects. It provides a learning and hands-on lab environment for students, but its high cost prevented further development. A lab such as this one would be a great marketing tool for both the College of Engineering and Northeastern University to attract future students to COE.