Different Lab Formats in Introduction to Engineering Course

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Different Lab Formats in Introduction to Engineering Course

Abstract

Many incoming freshmen are ambiguous about which engineering major they are interested in. Exposing them to different engineering labs in freshman year will help them have a clear understanding about different majors.

The objective of this paper is to find out a better way to deliver engineering labs to first year multidiscipline students. Mechanical and Electrical lab modules were used in this experiment. The mechanical module had four individual hands-on labs related to different aspects of mechanical engineering field, while electrical module used a project based learning approach. Each lab worked on certain portion of the project and the later labs were built onto the previous ones. A survey was conducted to collect data right after students completed the lab module to evaluate the content of the lab, as well as comparing the two different formats of the labs.

The survey data shows 72.8% of the students preferred individual hands-on labs, and 27.2% of the students liked the project based lab. Regarding to gender, there was no big difference among male and female students who favored individual labs, the percentage was 73.5% and 69.3% respectively. The preference was highly related to the content of the lab and the student's major. 93.6% of civil students preferred individual labs. This paper presents the design and implementation of mechanical and electrical lab modules, students' feedback, and findings.

Introduction

Introduction to engineering course is designed to help incoming freshmen to adapt to college life as well as exposing them to different engineering fields. It is a required course for all engineering major freshmen at Wentworth Institute of Technology. This type of course is not new to the community. Many colleges/universities have introduction to engineering for freshmen. However, most are offered in each department to fulfill the need for the department.

Laboratory exercises play an important role in engineering education[1-3]. They provide the opportunity for students to work on modern machines, tools used in industry. There are different ways to deliver labs: individual lab exercises and project based lab exercises.

Project-based learning is a dynamic method to inspire students to obtain a deeper understanding of the subjects, apply and integrate knowledge they are studying. Normally a project is a complex task, which involves design thinking, decision making, problem solving, etc.[2] Laboratory work helps students learn actively, hence it has been widely applied to many engineering subjects [4,5]. Many universities have developed hands-on, project based, first-year design courses to expose students to the application of engineering principles [6-10]. A similar

engineering design course is offered to all engineering major students as part of the common first year curriculum implemented at Wentworth Institute of Technology.

The objective of the paper is to find the effect ways to deliver engineering labs to multidiscipline students. Two types of lab format were implemented. Mechanical labs were designed to use individual labs, each lab was related to one subject, and no explicit connections between these labs. While Electrical labs were implemented using projected based learning approach, all labs were designed to complete a big project at the end. This paper presents our study with different lab delivery formats, including preparation, implementation, survey data, observations, and findings.

Course Background

Introduction to Engineering in our institution is a 3 credit course. The course includes one 1-hour lecture, and two 2-hour labs/week. In the lecture, students develop the skills needed during their study of engineering. Topics include task/time management, effective use of notes, engineering research, oral and written communications, problem-solving techniques, ethics and professional responsibility and institute resources. In the laboratory, students work in teams to complete a variety of engineering tasks.

Each class is set to 85 students maximum. The lecture is held at a big lecture hall. Regarding labs, students are divided into 5 different groups (section 2-6 in Table 1) to explore 5 different lab modules. The goal is to expose students to different engineering fields early in their career. The 5 lab modules are: Innovation and design thinking, Biomedical, Civil, Electrical, and Mechanical engineering. All lab sections are offered concurrently, lab instructors stay in the same assigned lab space and students rotate to different labs after completing the current one. Each student goes through the 5 different lab modules over the entire semester. Due to the amount of different modules, each lab module only has 2.5 weeks. Table 1 shows a typical lab rotation schedule.

Table 1. Typical Lab Rotation Schedule

	Module	9/1-9/18	9/19-10/7	10/8-10/23	10/27-11/11	11/12-11/23
TR 8-9:50AM	**Biomedical**	section -2	section -3	section -4	section -5	section -6
	Civil	section -3	section -4	section -5	section -6	section -2
	Electrical	section -4	section -5	section -6	section -2	section -3
	Mechanical	section -5	section -6	section -2	section -3	section-4
	Innovation/Design	section -6	section -2	section -3	section -4	section-5

Lab Implementation

Two types of lab delivery methods were implemented for the introduction to engineering course. Mechanical module was individual lab based. Individual labs covered various subjects in mechanical engineering field, but all threaded by mechanical design process. Electrical module was project based, which students worked on a project over the entire module. There were mixed majors in each section, students worked in teams on each lab, and most were multidiscipline teams.

Mechanical lab

The objective of mechanical lab was to expose students to various aspects of Mechanical Engineering field, including the latest technology and modern tools used in the field. With limited time, there were only 4 labs used.

Thermo fluid: Heat Engine was used to demonstrate the principle of Thermodynamics. This lab used a PASCO Heat Engine apparatus and air chamber, with hot and cold bath.

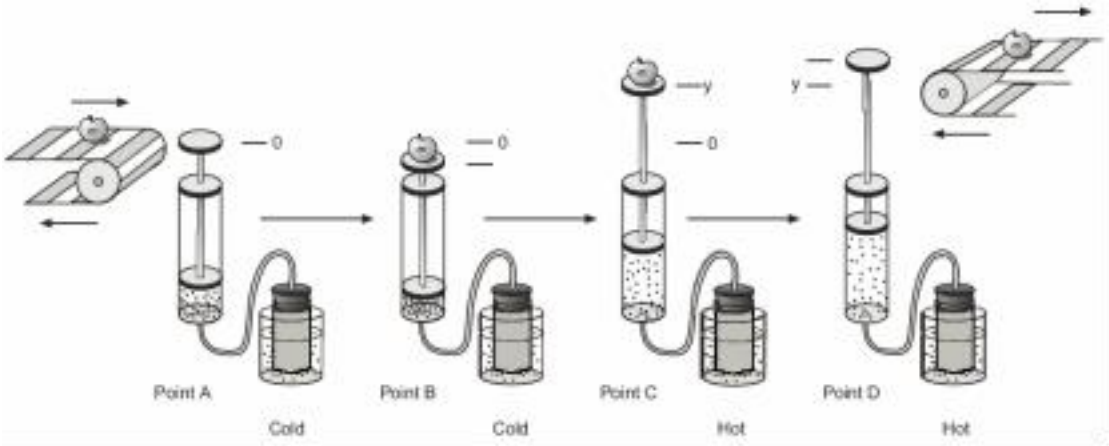
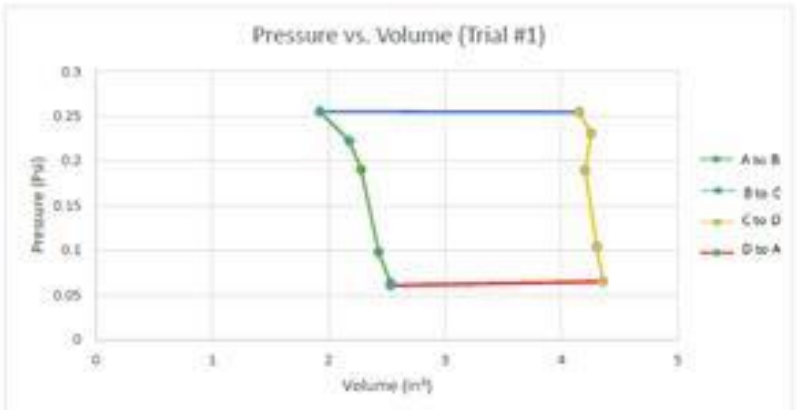


Figure 1. Heat Engine Weight Lifting diagram[11]

When the air chamber was moved from the cold bath to the hot bath, the piston moved up and lifted the mass. When the chamber was moved back to the cold bath, external air entered the chamber through a one-way intake valve. Repeating the cycle caused the mass to continue to rise. Pressure-Volume (P-V) diagram was then created and the total thermodynamics work was calculated. The experiment setting and a typical PV diagram is shown in Figure 2.



(a) (b)

Figure 2. Heat Engine experiment (a) and a typical PV diagram (b)

Solid Mechanics: The design of a machine is a complex procedure. The general steps involved in machine design are:

- Kinematic Scheme – Determining the motions necessary to accomplish the objective of the machine. It is the geometry information of the machine.
- Forces Involved – Determining the directions, magnitudes and points of application of the external forces, and the motion of the machine, including the velocity and acceleration.
- Proportions and Materials - Deciding on the general shape, size and material for each part so that it can successfully resist the forces involved.
- Detail Designing – Specific dimensions, tolerances, fits, manufacturing methods, lubrication methods, assembly methods, bearing types, fasteners, surface qualities, and protective coatings, etc.

Based on the general design procedure. Three labs were developed in solid mechanics area:

- *A Kinematic lab* – Designing a linkage (windshield wiper)

This lab was used to introduce students to the kinematic field. In this lab students designed a four bar linkage system and simulated the motion in WorkingModel software. At the end, a physical model using popsicle sticks, screws, threaded bolts, etc. was required. Advanced students built the real windshield wiper system in WorkingModel environment (Figure 3).

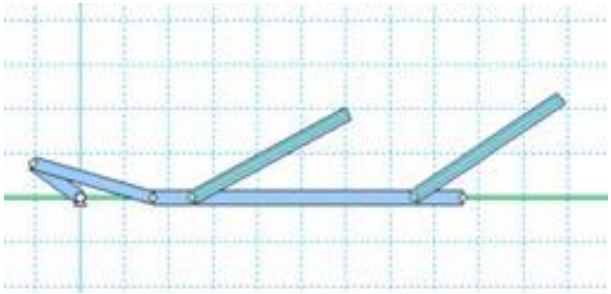
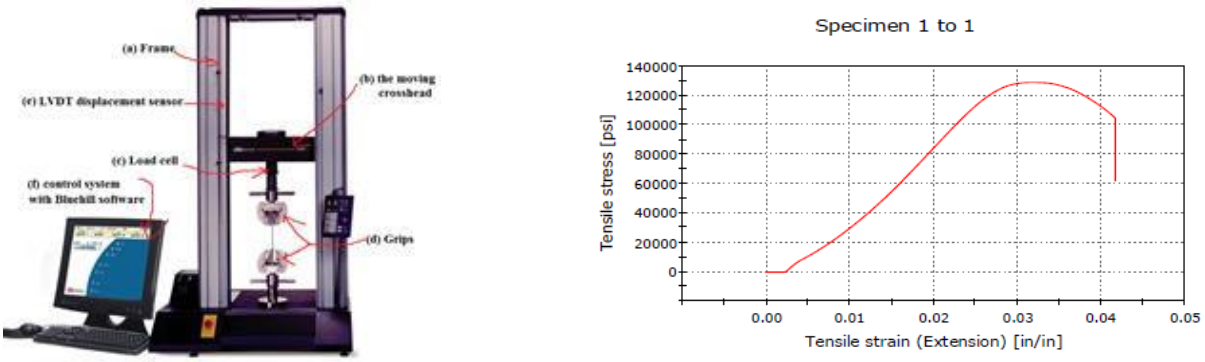


Figure 3. Windshield wiper model

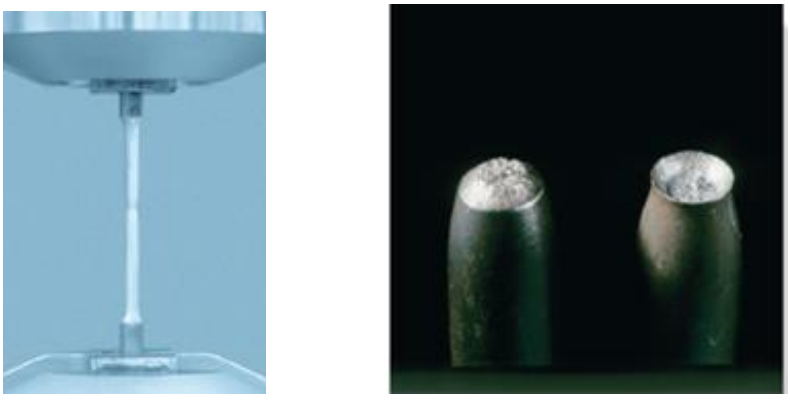
- *Rigid body Motion* – Analyzing the velocity and acceleration of a simple rigid body and gears. In this lab, students used WorkingModel software to simulate the motion of a rigid body and a set of gears.

- *Tensile test* – Testing the properties of different materials: steel and aluminum using Instron Universal test machine.



(a) (b)

Figure 4. Instron Universal Test Machine (a) and a typical stress strain diagram (b)



(a) (b)

Figure 5. Typical Necking pattern before a steel/aluminum sample fracture (a) and the "cup cone" shape at fracture location (b)

Electrical Lab

The objective of Electrical lab was to expose students to Arduino microcontroller to encourage student engagement by a fun project-----Autonomous Vehicle with sensors. The project included 4 sequential labs: Lab 1 Pulse Width Modulation, Lab 2 Arduino Pulse Width Modulation, Lab 3 Sensors and Conditionals, and Lab 4 Autonomous Vehicle.

Pulse Width Modulation: the students were introduced to the basic benchtop instrumentation: function generator, oscilloscope and power supply. The challenge was to generate pulse-width

modulation (PWM) periodic square waves to control a continuous stepper motor. This exposed the students to basic electrical engineering concepts of time-course signals, voltages, frequency and manipulations of periodic signals.

Arduino Pulse Width Modulation: instead of using the bench top instrument of a function generator to make the PWM signal, the students needed to write software on an Arduino microcontroller. With software and the microcontroller board, the students generated the same PWM signals that they had previously made with the function generator.

Sensors and Conditionals: sensor input to the microcontroller was introduced. Students activated sensors, setup analog-to-digital conversion on the microcontroller, and utilized the new information to generate the PWM signals controlling the motors. Using a digital multi-meter (DMM), they observed the change in voltage from the sensor as the measurand (color on the floor observed by the sensor) changed. Following analog-to-digital conversion on the microcontroller board, they observed the number from the sensor as used within the software program. Based on what they learned, they setup a threshold within the software.

Autonomous Vehicle: the students utilized their prior skills to develop a target behavior for their car. The goal was to have the car generally move forward, but to stay within an arena defined by the border of a white line ring around a black floor in the interior of the ring.

Survey Questions

A survey was conducted to collect data right after students completed the lab modules to evaluate the content of the lab, as well as comparing these two different types of lab format. Due to the nature of the course, all engineering major students took the same class together, the survey asked their major and gender. Following was the question we asked students:

If you have two options, which one do you prefer and why?
(a) One big project (utilize all lab times working on the project)
(b) 4 individual labs

Survey Results

There were 81 students participated the survey. 72.8% of students preferred individual labs. The overall percentage of students who favored individual labs is shown in Figure 6.

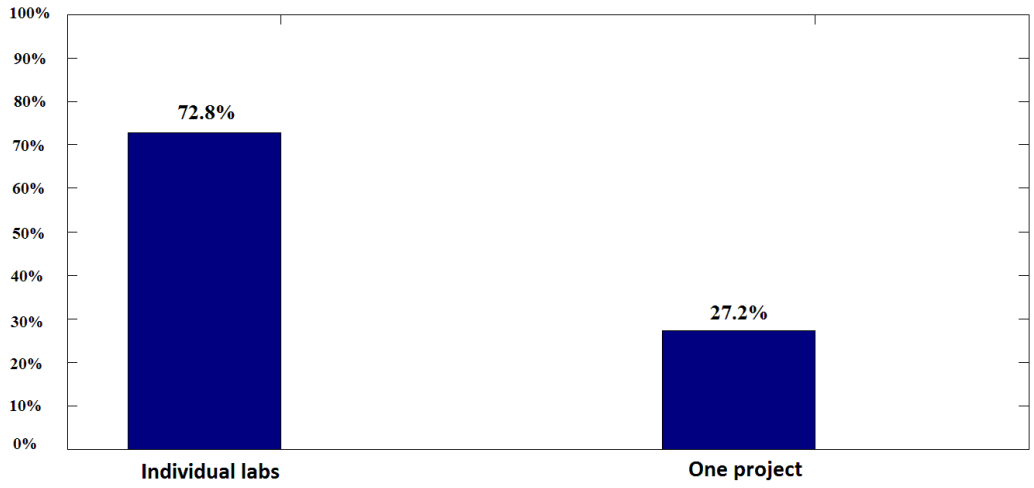


Figure 6. Overall preference of lab format

Seven different major students took the introduction to engineering course: Biomedical, Civil, Computer, Electrical, Electromechanical, Interdisciplinary, and Mechanical Engineering. The percentages of students who favored individual labs based on different majors and genders are shown in Figure 7 and Figure 8 respectively.

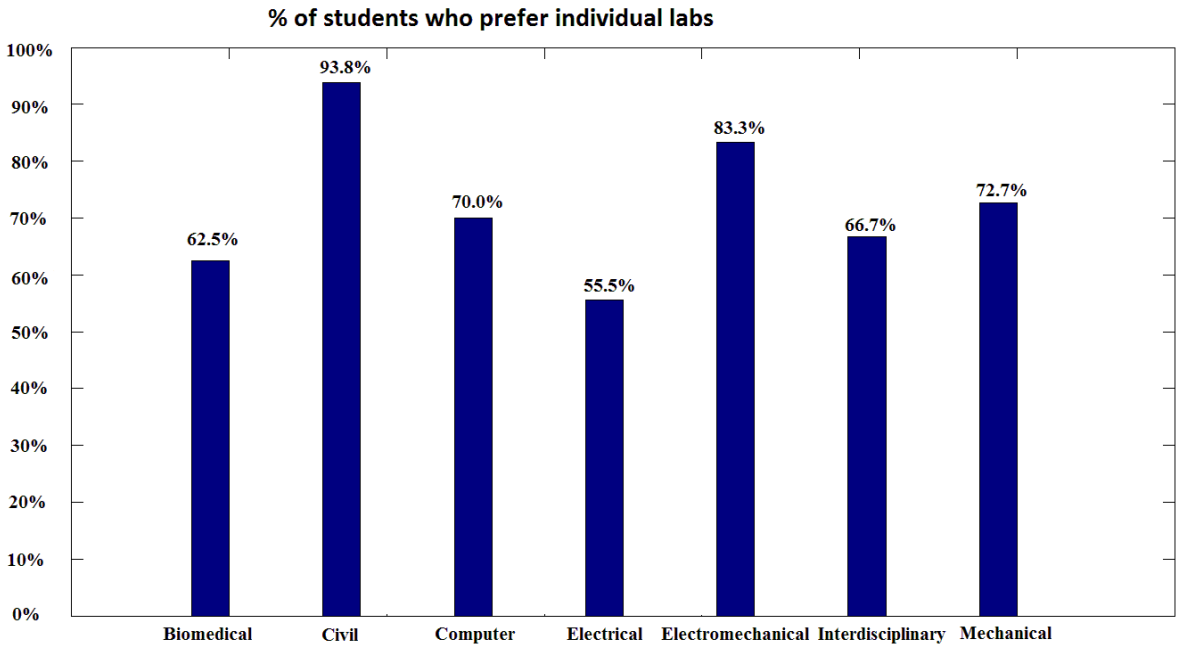


Figure 7. Survey result based on different majors

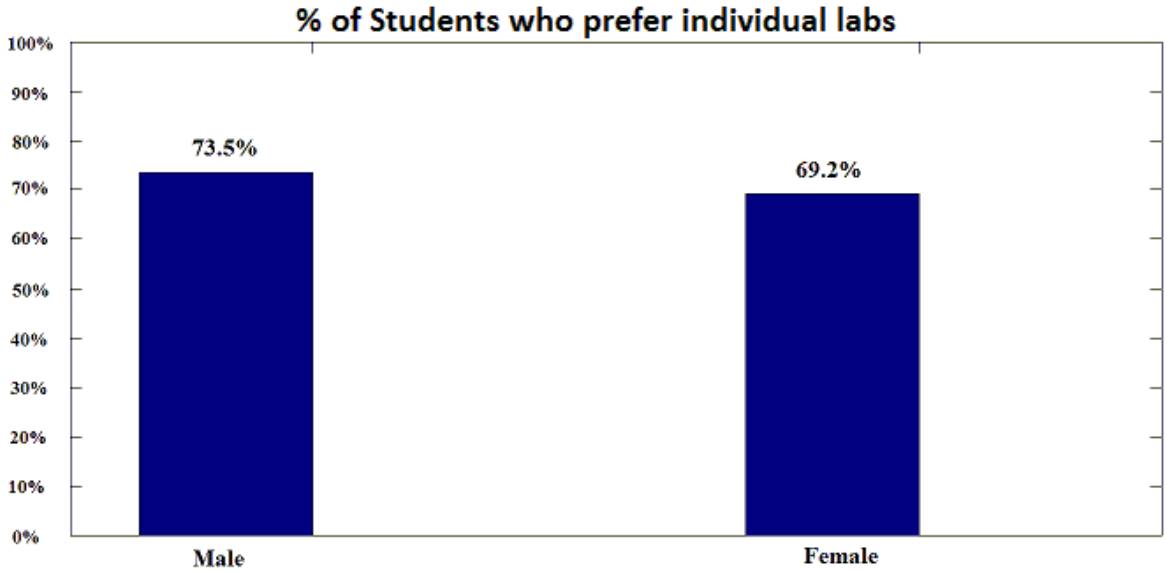


Figure 8. Survey result based on gender.

From the survey results we can see that most students preferred individual lab exercises, in terms of major, most Civil engineering students liked individual lab exercises. Electrical engineering students liked project based lab.

Some of the comments from students who preferred individual lab exercises are: “Allow for a diverse understanding for the field”, “It shows different areas of mechanical lab”, “Easier to understand, make it more manageable”, “Give people multiple ideas on mechanical engineering”, “It makes learning the concepts easier when you focus on one at a time.”, “Less stressful”, “It's much more broad”, “Nice to try and use different things without the pressure of a large project”, “Give you a taste of the major more variety”, “Allow us to learn different areas in mechanical engineering”, “Cover more topic materials”, “More manageable”, “I will be less stressful if we can perform four easy individual labs”.

There are two main reasons that students preferred individual lab exercises: 1) students were exposed to different areas of mechanical engineering. They had a diverse understanding for the field. 2) it was less stressful to manage 4 individual labs. When working on one big project, if students did not finish one lab on time, it would be tough to finish the following labs to complete the project on time.

Some of the comments from students who preferred project based lab are: “One big lab sounds more in depth and interesting to me”, “it would be more in depth and less repetitive”, “Lead to develop skills and show how they work together”, “It lets you focus on just one thing and doing great on it”.

There is one main reason that students preferred project based lab: students just focused on one topic and went more in depth in that area during the 2.5-week module. There are couple of reasons that students did not prefer project based lab: 1) It took longer time to complete Electrical labs. On the last day lots of students didn't have much time. 2) There were five different lab modules for this course, students were tired of doing one project. They wanted to switch their minds from one topic to another. They might just prefer easy work, which makes them lean towards traditional individual labs.

Lab subject matter played an important role when students chose their preferences. Survey data shows that over 90% of Civil engineering freshmen preferred individual labs. Maybe simply because they were not familiar with Electrical engineering, and the project was difficult for them. Some evidence can be found from student's survey response "I did not like Electrical engineering at all".

The introduction to engineering course is designed to expose students to different engineering fields, give students the opportunity to judge whether they are really interested in the major they choose. After the course, some students switched their major. Different major students treated each lab module differently. For example, majority of Mechanical major students preferred individual labs because mechanical lab happened to be the individual lab format. The survey data shows many Electrical major students preferred utilizing all lab times to work on a big project. The main reason is that they were interested in electrical engineering field regardless of the format of the module. When analyzing preferences of other major students, the results show most Civil engineering students liked the individual lab format.

Conclusion

This paper describes the development of Mechanical and Electrical lab modules (two of five modules) for an introduction to engineering course, which was offered to freshman engineering students from seven different majors at Wentworth Institute of Technology. Mechanical lab was developed using individual lab format, while electrical lab was designed using project based learning approach. Survey data was collected right after students completed the lab module. Survey results show that most students preferred the individual labs due to its features: easy to complete, less pressure, wide explosion to different fields of the major. Most students preferred individual labs while there was a big difference between the lab contents and the student's major. For example, 93.8% of Civil engineering students did not like project based electrical lab. For the introduction to engineering course, we believe individual labs give students a broader view of the engineering major. Project based labs might fit better in technical courses, in which students have more time to work on it and get deeper understanding of certain subject.

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