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Hands-On Modules for First-Year Civil Engineering Students

Dr. Andrew Paul Summerfield, Wentworth Institute of Technology
Will Cashel-Cordo

Lab Tech Civil Engineering

Hadi Kazemiroodsari, Wentworth Institute of Technology

Hadi Kazemiroodsari is assistant professor at Wentworth Institute of Technology. He earned his PhD in Geotechnical engineering from Northeastern University. His area of expertise are Geotechnical engineering and Earthquake engineering.

Work in Progress: Hands-on Modules for First-Year Civil Engineering Students

Abstract: This paper is a Work in Progress. Student engagement and retention in first-year engineering courses are typically challenging. Many engineering programs offer a general "Introduction to Engineering" course for first-year students, and designing interactive and engaging modules for such courses is essential for retention. We present several new modules for hands-on learning that would be excellent additions to an Introduction to Engineering course. The goal of these modules was for students to gain a qualitative understanding of the basic theoretical concepts relevant to several subdisciplines of civil engineering, including structural, environmental, geotechnical, and transportation. This paper describes the modules in detail and summarizes student feedback and retention data. This paper is a work-in-progress that will continue until the students graduate.

Background and Motivation

The authors teach in the school of engineering at an undergraduate-focused university. The authors' institution is in the midst of redesigning its introductory engineering courses. This redesign started about two years ago and was prompted by low retention of first-year engineering students. The first-year engineering program is still evolving, but at this stage of the redesign, there are two courses that all first-year students enrolled in the school of engineering must take: a course in the ENGR 1200 series, which is the subject of this work, and ENGR 1100. Sections of ENGR 1100 include students from all disciplines of engineering, as well as undecided students. The course introduces students to engineering through discussion of broad topics like the definition of engineer, engineering design, engineering ethics, professional societies, and so on. The ENGR 1200 series, by contrast, is a lab course that is designed to be specific to different disciplines of engineering: civil, mechanical, and so on. ENGR 1203 is the course at our institution for first-year students who have enrolled in the civil engineering degree program.

The redesign of our institution's first-year engineering program is part of a broader trend in higher education to develop curricula specifically for first-year engineering students [1]. This broader trend is motivated in large part by low retention of first-year engineering students [2] [3]. Literature suggests that two course components can help to attract and retain students: 1) the opportunity for hands-on learning [4] [5] and 2) the provision of clarity on what it means to be an engineer [6]. This research has guided the redesign of the first-year engineering curriculum at our institution, and in particular, the design of the ENGR 1200 series.

In this paper, we present several modules we designed for ENGR 1203, which was offered for the second time in the Fall 2023 semester. Included are several modules that were adapted from previous modules and several modules that have not been offered before. We show that these modules were viewed favorably by students. Our goal in sharing this work is to provide instructors at other institutions in the midst of first-year program redesigns with a strong starting point in the form of ready-to-use and easily adaptable modules.

Goals of Course

ENGR 1203 is the course at our institution for first-year students who have enrolled in the civil engineering degree program. The goals of ENGR 1203 are 1) to give students an understanding of the industry their education is leading them towards, 2) to demonstrate what sorts of math and science skills they will learn, and 3) to give students the opportunity to do hands-on experiments. The hope is that achieving these three goals will help retain students who have started the civil engineering degree program, or at the very least, give them clarity on what it means to study and work as a civil engineer.

The syllabus states "Through a series of hands-on laboratory experiments, students will develop working knowledge in the use and application of modern engineering tools and techniques required for engineering practice." The syllabus is admittedly too vague and was partially adapted from a previous version of a first-year engineering course. The authors will revise the course objectives for future versions of the course to be more in line with the three goals listed above.

Design of Course

To meet the three course goals described above, we used the following simple approach to design the course modules: 1) identify a subdiscipline of civil engineering, 2) identify a physical concept that is relevant to that subdiscipline, 3) design an activity that gives students hands-on experience testing that physical concept.

With this simple approach in mind, we planned one lecture and one lab for each module. The lecture consisted of two components:

1) A broad overview of the civil engineering subdiscipline for that module, including discussion of the societal role played by practitioners of that subdiscipline, relevant and well-known projects, and examples of typical day-to-day responsibilities
2) A basic qualitative explanation of physical concepts relevant to that subdiscipline, emphasizing connections to other courses students might already be familiar with, such as chemistry and physics

We designed hands-on lab activities to achieve two outcomes:

1) Provide a demonstration of the physical concept introduced in the lecture
2) Provide students the opportunity to work in groups with minimal instructor guidance

Course Content

Table 1 provides an overview of the civil engineering subdisciplines covered in each module, the relevant physical concept, and the name of the hands-on lab activity.

Table 1. Overview of ENGR 1203 Modules

Module	Subdiscipline	Concept Introduced	Lab Activity
1	Structural	Hooke's Law	Spring Lab
2		Tension and Compression	Foam Beam
3		Design and Construction	Spaghetti Bridge
4	Geotechnical	Soil Shear	Reinforced Earth
5	Environmental	Water Quality	Flocculation
6		Carbon Footprint	Life Cycle Assessment
7		Buoyancy	Determining Specific Weight
8	Site Civil	Topography	Drawing a Profile
9	Transportation	Mobility	Google Maps Activity

Note that the modules were not presented in this order. With the exception of Module 3: Spaghetti Bridge, each module took one week and so consisted of one lecture period and one lab period. The Spaghetti Bridge module took three weeks, so students had a total of three lecture periods and three lab periods to design and construct their bridges. Three of the lab activities—Life Cycle Analysis, Drawing a Profile, and the Google Maps Activity—are paper/laptop labs. The intent was for all lab activities to be hands-on, but due to certain time and equipment restraints, we asked students to conduct these three lab activities entirely on paper or on their personal laptops. Fortunately, these three lab activities provided a useful standard for comparison in assessing the student feedback. See the Student Feedback section for further discussion.

Brief descriptions of the lab activities are as follows. Full lab sheets can be found in Appendix A.

Structural

1) Spring Lab—We asked students to experimentally determine the stiffness of different springs. We provided them with hanging springs, weights, and rulers. Students had to add weights, record displacement, create force-displacement graphs from their data, and rank the springs from lowest to highest stiffness.
2) Foam Beam—We asked students to increase the bending strength of a foam beam (16" long with a 2"x2" cross section) by adding a single strip of duct tape. In groups, students had to sketch several designs for duct tape application, choose the one they thought would perform the best, and then apply the duct tape. We tested their designs by adding weight to the middle of a span, with the foam beam supported at either end.
3) Spaghetti Bridge—We asked students to design a bridge using only spaghetti and hot glue. We provided each team with 2 pounds of spaghetti and a set amount of hot glue. Each team had to sketch a design and provide connection details before construction. We tested each bridge to failure by hanging a 5-gallon bucket from the bottom with string that passed over the bottom chord and adding sand to the bucket. Students designed and constructed their bridges over the course of three weeks.

Geotechnical

1) Reinforced Earth—We asked students to engineer columns of sand for maximum strength under compressive loading. The design parameters students controlled were the sand type (Ottawa and concrete sand), the water content of the sand, the reinforcing material (cloth, paper towels, and wire mesh), and the number and spacing of reinforcing layers. Students built their columns of sand in cups. We tested their designs by adding weights to a platform resting on the top of their sand columns. This experiment was based on the experiment conducted in [7].

Environmental

1) Flocculation—We asked students to filter high-turbidity water using in sequence a sieve, a flocculating agent, and one of three filters (a sand filter, a coffee filter, and a hiking filter). Students had to record their observations of the flocculation process and explain why the experiment was conducted in the given sequence (sieving-flocculation-filtration). The water quality experiment was based on the experiment conducted in [8] and the lecture content drew from the content in [9].
2) Life Cycle Assessment (laptop lab)—We asked students to calculate the total carbon footprint of three of their favorite meals by looking up the carbon footprints of the individual ingredients on the ClimateHub database [10]. Students then had to use Excel to create tables, pie charts, and a bar graph showing how the total carbon footprint of each meal was broken out by ingredient and by phase of production. Students also had to answer questions about the interpretation of quantities like "carbon footprint" and about what roles civil engineers might play in reducing emissions.
3) Determining Specific Weight—We asked students to determine the specific weight of water by exploiting the concept of buoyancy. The testing apparatus consisted of a beaker with a hook held to the bottom by a magnet underneath the beaker. A string was passed through the hook. One end of the string was attached to a foam cube. The other end of the spring was attached to a spring with a force reading. Each group of students filled their beaker with tap water and pulled on the spring to submerge the foam cube in increments (one-quarter submerged, half-submerged, etc.). Students recorded the force in the spring and the change in volume in the beaker at several increments and then repeated the experiment with salt water. Students then had to create graphs of force versus change in volume for each experiment and interpret the results.

Site Civil

1) Drawing a Profile (paper lab)—We asked students to create topographic maps by connecting points of the same elevation. We also asked students to use their topographic maps to draw profiles between different points. Topographic worksheets were taken from [11] and so are not included in Appendix A. The intent was for this lab to include a component where we 3d-printed their topographic maps. However, due to time constraints, we could not implement this component, so students completed the lab entirely on paper. See Student Feedback section for further discussion.

Transportation

1) Google Maps Activity (laptop lab)—We asked students to use Google Maps to assess problematic intersections, consider ways of restoring waterfront access to cities whose access had been obstructed by highways, and to compare commute times by different modes through regions of different population density. This activity involved reading and interpreting maps and assessing efficient ways to direct or redirect the movement of people.

Student Feedback and Retention

The student course evaluations for all courses consist primarily of multiple choice, "strongly agree/disagree" style questions. To supplement the standard course evaluations, the instructors for ENGR 1203 also included free-response questions to assess students' feelings about the structure and content of the class and whether the course goals had been achieved. A total of 44 students were enrolled between two sections of the course and a total of 29 of these students responded to the survey. However, not all student respondents answered all free-response questions. The full list of free-response questions and student responses is included in Appendix B. Some responses to three questions in particular provide useful insight.

Q1: Do you feel like this class gave you a good overview of the different subdisciplines of civil engineering? Why or why not? (20 responses out of 29 survey respondents)

- "This class gave us a good overview of how broad civil engineering can be."
- "Each lab covered a different kind of civil and I gained a solid idea of what each one entails in some of its coolest applications."
- "It helped me narrow down a focus in civil engineering."
- "Yes, this class gave me a good idea of what each subdiscipline does in civil engineering. Which also makes my intended target discipline clearer."
- "Yes it made me understand the different sub disciplines and figure out which was for me."

Q2: Which lab activity was your favorite? Why? (21 responses out of 29 survey respondents)

- 14 responses out of 21 total responses to this question included Spaghetti Bridge.

Q3: Which lab activity was your least favorite? Why? (19 responses out of 29 survey respondents)

- 11 out of 19 total responses to this question included Life Cycle Assessment, Drawing a Profile, or the Google Maps Activity.

The responses to Q1 demonstrate that students found that the course gave them clarity on what it means to be an engineer. The responses to Q2 and Q3 demonstrate how much students enjoy hands-on learning: the Spaghetti Bridge activity was the activity that involved the greatest amount of hands-on work, while Life Cycle Assessment, Drawing a Profile, and the Google Maps Activity were the activities that involved the last amount of hands-on work. There is also anecdotal evidence for the strong preference for hands-on learning: during lecture, one instructor asked the students whether they identified as hands-on learners, and nearly all students raised their hands.

We will assess data on student retention in two ways: 1) how many students who were enrolled in ENGR 1203 in Fall 2024 remained in the civil engineering degree program for Spring 2025 and 2) how many students who were enrolled in ENGR 1203 in Fall 2024 remained in the civil engineering degree program for Fall 2025.

Conclusions

In this paper, the authors presented several modules of a course (ENGR 1203) for first-year engineering students. The purpose of ENGR 1203 is 1) to give students an understanding of the industry their education is leading them towards, 2) to demonstrate what sorts of math and science skills they will learn, and 3) to give students the opportunity to do hands-on experiments.

Student feedback demonstrated that the course was successful in providing students with greater clarity about the field of civil engineering and that students strongly prefer hands-on activities over paper-based or laptop-based work.

The authors hope that this work can provide instructors at institutions that are also revising or creating first-year engineering programs with a strong starting point. The work includes some ready-made modules that can be used as they are or easily adapted. The simple framework for designing modules—identifying an engineering subdiscipline, identifying a relevant physical concept, and designing a lab activity to test that concept—will hopefully facilitate the process of syllabus creation.

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Appendix A

ENGR 1203
Module 1: Spring Lab

Name:

Group members:

Prelab Question:

When we perform the experiment, we are going to add several different weights to the spring and measure how much the spring stretches under each weight. If the spring deflects 1.5 inches under the first weight, how much will it deflect if the second weight is twice as heavy as the first weight?

Discussion Questions

1) For each spring tested, create an Excel graph with the applied weight on the y-axis and the displacement on the x-axis.
2) Do the plotted points form straight lines?
3) For each graph, add a line of best fit and find its slope.
4) What do the slopes represent?
5) Which color spring was the stiffest? How do you know?
6) Do the results from our experiment match your answer to the prelab question?

To Submit on Brightspace:

1) A pdf with the graphs and your answers to the questions above

ENGR 1203
Module 2: Foam Beam

Procedure

Use your allotted duct tape to make your foam beam strong enough to hold more weight than the sample foam beam.

Discussion Questions

1) Who were your group members?
2) What strategies for applying the duct tape did your team use? Include pictures. What was your rationale for using these strategies?
3) Which strategy was the most successful? Why?
4) Did other groups have a more successful strategy? What was it and why was it more successful?

ENGR 1203
Module 3: Spaghetti Bridge

Overview
The goal of this project is to design and construct a bridge using spaghetti and glue. The bridge must have a clear span of 16 inches. Bridges will be loaded by a point load applied at the midspan of the bottom chord. Load will be increased until the bridge collapses. Bridges will be ranked according to efficiency: the ratio of load held at breaking to bridge self-weight.

Design Requirements:

- Clear span: 16 inches
- Maximum bridge length: 20 inches
- Bridge width: 6 inches
- Loading: point load applied to the bottom chord at midspan

Materials:

- 3 pounds of dry spaghetti
- Glue gun
- 1 package of glue sticks

Assessment Criteria:

- Ratio of maximum load held to bridge self-weight: $E = P_{max}/W$

Deliverables:

- Bridge Type Study (Class 1)
- Final Design Drawings (Class 1)
- Bridge Analysis (Class 2)
- Spaghetti Bridge (Remaining Classes)

All Deliverables except for the spaghetti bridge itself are to be submitted on Brightspace.

Class 1: Bridge Type Study

Background

When engineers are tasked with a design problem, they first might want to conduct a type study to explore their options for how to proceed. In a type study, engineers will compare several different structure types to determine which structure is best suited to the problem. For instance, if engineers are hired to design a bridge that will span a river, they first might consider whether a suspension bridge, a cable-stayed bridge, or a truss bridge would work best. If they select a truss bridge, they will then compare different truss types before proceeding with a more detailed design.

For our project, we have already determined that our spaghetti bridge will be a truss bridge. But before you start designing, you need to consider some truss type options.

Assignment

Work individually to research different truss types and sketch a preliminary design for your spaghetti bridge. Compare your preliminary design to those of the other members of your group. You don't need detailed dimensions about the member lengths just yet, but consider general questions of geometry:

- Is it better to have longer or shorter members?
- Should each truss panel be as long as it is high?
- Considering that the load will be placed at midspan, is it better for the truss to be symmetric or asymmetric?
- What basic shape seems like it would be the strongest?

Once you have consulted with your group members, pick the three preliminary truss designs that seem like they would be the strongest. Sketch these on a single sheet of paper and answer the following discussion questions.

Discussion Questions

1) How did you select these three preliminary designs?
2) Which of these three preliminary designs do you think would be the strongest? Why?
3) Which of these three preliminary designs do you think would be the easiest to construct? Why?
4) Pick one to be your final design and defend your choice!

Deliverables

1) Sketches for three preliminary designs
2) Discussion Questions 1-4

Class 1: Final Design Drawings

Once you have picked a truss type from your type study, you need to produce design drawings for your final design. Design drawings are the set of drawings issued by an engineer which show how a structure is to be built. The contractor will use them to arrive at a cost estimate for construction and will ultimately use these drawings, as well as their own supplementary drawings, to construct a structure.

In this case, you are both engineer and contractor! (I am the project owner.) The drawings you produce will be the record of your design and a reference for how to proceed with construction. Include dimensions where necessary and notes about materials or construction.

Deliverables

On the 11x17 paper provided, draw the following:

1) One longitudinal elevation (with dimensions)
2) One transverse section (with dimensions)
3) One isometric view
4) One connection detail

ENGR 1203
Module 4: Reinforced Earth

Part 1: Effect of Water on Soil Strength

Procedure

1) Pick a sand type: Concrete or Ottawa.
2) Make a structure out of **dry** sand and test its strength by applying load.
3) Take note of the approximate angle of repose—its approximate height divided by the approximate distance from the highest point to the edge…
4) Can it support any load?
5) Repeat the test with (a) wet and (b) very wet sand.

Discussion Questions

1) What differences did you find between the 3 tests? Why could these variations be occurring?

Part 2: Effect of Water on Soil Strength—Repeated

Procedure

1) Pick a new sand type and repeat the strength tests for (a) dry, (b) wet, and (c) very wet sand.

Discussion Questions

1) Did you notice any physical differences between the sand types (Concrete and Ottawa)? If so, what are these differences and how might they affect whether the sand is useful for construction?

Part 3: Reinforced Soil

Procedure

1) Pick one sand type and one water content (dry, wet, or very wet).
2) Use the sand type/water content combination you selected to make three reinforced soil structures: (a) soil reinforced with red towels, (b) soil reinforced with mesh, and (c) soil reinforced with Kimtech wipes.
3) Repeat the strength test for each of the three reinforced soil structures.

Discussion Questions

1) Which combination of sand type and water content did you pick and why?
2) Did the reinforced soil structures have different outcomes than the unreinforced soil structures? If so, which reinforcement was best? Did any of them surprise you?

General Discussion Questions

1) Not all soils are equally as useful when it comes to building foundations. Look up what makes a soil good for slope stability and explain what you found.
2) Did you notice water coming to the surface while compacting? This is called liquefaction. Can you think of a process that could produce this on a large scale suddenly?

ENGR 1203
Module 5: Flocculation

Set-Up
Each group should have:

- 1 large beaker
- 1 small beaker containing flocculant

Experimental Procedure

1. Read the entire Experimental Procedure, Clean-up Procedure, and Discussion Questions before you start performing the experiment.
2. Use the batching beaker at the front of the room to strain high-turbidity water through the sieve into your beaker. Add a total of 600mL of high-turbidity water to your beaker. This is your sample of high-turbidity water.
3. Record the pH of your sample.
4. Record qualitative observations of your sample, including such characteristics as color, smell, and how well light penetrates through the sample.
5. Add the flocculant to your sample.
6. To stir your sample with the stirrer for 5 minutes.
7. Once you have stopped stirring your sample, let it sit for 20 minutes. Record the pH and qualitative observations of your sample at 5-minute intervals, i.e., at 5 minutes, 10 minutes, 15 minutes, and at 20 minutes.
8. After 20 minutes, compare your sample to the control sample. Record your observations. Take pictures.
9. Pour your sample through one of the three filtering apparatuses (the sand filter, the paper filter, or the bag filter).
10. Compare your flocculated and filtered sample to the control sample and record your observations.

Clean-up Procedure

1. **DO NOT POUR ANY WATER DOWN THE DRAIN IN THE ENVIRONMENTAL LAB.** The sink in the environmental lab does not have a sediment trap, so the dirty water from this experiment will clog the drain. Rinse the dirty glassware into either 1) the sink in the geotechnical lab or 2) the 5-gallon bucket. If you are unsure what to do, ask for help.
2. Use paper towels to wipe down the stirrers and any spills.

Discussion Questions

1. Describe what you observed. Would you describe your sample in its final stage as low-turbidity water? How quickly did the sediment settle? Was more than 20 minutes necessary?
2. Why did the pH of the water change?
3. There were some components floating in the water. Why did the flocculant not cause these samples to settle out?
4. What was the purpose of straining the initial raw water?
5. What was the purpose of pouring the water through the filter after flocculation?
6. Why did we not pour the water directly through the filter? In other words, why did we not skip the process of flocculation and go directly to filtering?
7. What additional steps would you take to make the water potable?

ENGR 1203
Module 6: Life Cycle Assessment

Use the following carbon footprint database to find the kg CO_2e/kg for each ingredient.
https://apps.carboncloud.com/climatehub/search?q=pizza&market=USA&sort=market%3Adesc

Deliverables

1. **One table** showing total kg CO_2e/kg for each meal (three rows, one column)
2. **Three pie charts**, one for each meal, showing what proportion of the total impact is caused by each ingredient
3. **One bar graph**, showing how the total kg CO_2e/kg breaks out by "phase" (agriculture, transportation, etc.)
4. Discussion Questions

Discussion Questions

1) What is a kg CO_2e/kg?
2) What impacts are not included in the metric we used for this analysis (kg CO_2e/kg)?
3) Why does agriculture represent the majority of the CO_2 emissions for some ingredients?
4) What kinds of ingredients had significantly higher levels of kg CO_2e/kg? What kinds of ingredients had significantly lower levels of kg CO_2e/kg? How do you explain this? Does your bar graph, showing the impacts by phase, shed any light on these differences?
5) What are some of the specific impacts included in the total impact for produce items?
6) List two examples of interventions that civil engineers could make to reduce some of the impacts of these ingredients. Is there a particular phase (agriculture, transportation, etc.) in which engineers are likely to have the greatest impact?
7) List some of the different parties (companies, governments, individuals, etc.) that are involved in the life cycles of these ingredients. Who is responsible for the impacts?

ENGR 1203
Module 7: Determining Specific Weight

Set-Up
Each group should have:
- 2 beakers

Experimental Procedure
1. Read the entire Experimental Procedure, Clean-up Procedure, and Discussion Questions before you start performing the experiment.
2. Fill your 2 beakers with 700mL of tap water.
3. Add salt to **one (1)** of your samples of water, at a concentration of 35 g/L.
4. Record the volume, mass, and temperature of each of your 2 water samples.
5. Pour your sample of clean water into the beaker with the test apparatus. Check that the volume reading on the test beaker matches the volume you recorded in Step 3.
6. Pull on the spring and submerge about 1/4 of the foam block's volume. Hold the block steady while you record the force reading in the spring **AND** the beaker's volume reading at the new water elevation.
7. Repeat Step 5 with 1/4 of the block's volume submerged, with 1/2 of the block's volume submerged, with 3/4 of the block submerged, and with the entire block just submerged (so that the top surface of the block is barely covered with water).
8. Repeat Steps 5 and 6 with your salt water sample.

Clean-up Procedure
1. **DO NOT POUR ANY WATER DOWN THE DRAIN IN THE ENVIRONMENTAL LAB.** The sink in the environmental lab does not have a sediment trap, so the dirty water from this experiment will clog the drain. Rinse the dirty glassware into either 1) the sink in the geotechnical lab or 2) the 5-gallon bucket. If you are unsure what to do, ask for help.
2. Use paper towels to wipe down the stirrers and any spills.

Discussion Questions
1. Use the values for volume and mass you recorded in Step 3 to calculate 1) the density and 2) the unit weight of each sample of water.
2. In Excel, create a chart of force and volume increase for each of your 2 water samples.
3. In Excel, make a graph of force versus volume. Plot the values for force and increase in volume for each of your 2 water samples on the same graph.
4. Add a linear trend line for each set of points and include the equation of each line.
5. What is the meaning of the slope of each trend line?
6. Compare the density of your clean water to the density of your salt water. Explain any differences.
7. Compare the values for density and unit weight you calculated to published values. Why might your calculated values be different than the published values? What variables aside from volume and mass could affect the density?
8. What are several factors that might have affected your force readings?

ENGR 1203
Module 9: Google Maps Activity

Part A: Redesign Troublesome Intersections
Learning Objectives:
- Learning about design alternatives for the same problem.
- Balancing multiple design objectives.

Design of interchanges and intersections can require a great deal of thoughtfulness and creativity on the part of a transportation engineer. The following figures show an intersection in Cambridge (Figure 1) and an interchange in Boston (Figure 2). The two reference articles list some recommendations for handling such design problems.

Reference Articles:
1) Strategies for Safer Urban Intersections
2) Interchange Design Alternatives

Procedure and Discussion
1) Find articles on that internet that discuss the problems with the two locations pictured in Figure 1 and Figure 2. List some of your findings.
2) Add red boxes around areas that you identify as obstacles to the flow of traffic. Explain why you identified these areas.
3) Add blue circles around areas that you identify as dangerous for pedestrians or cyclists. Explain why you identified these areas.
4) If your only goal is to maximize traffic flow, which design recommendations from the Reference Articles would you use?
5) What other considerations would prevent you from taking the steps above?
6) If your goal was to improve both safety and traffic flow at the intersection/interchange, what design recommendations would you use? Are there other design alternatives not mentioned in either Reference Article that you think would be helpful?

Pro-tip: Use the “snip” tool (or the Mac equivalent) to take screenshots and Microsoft Powerpoint to add shapes, outlines, shaded areas, and labels.

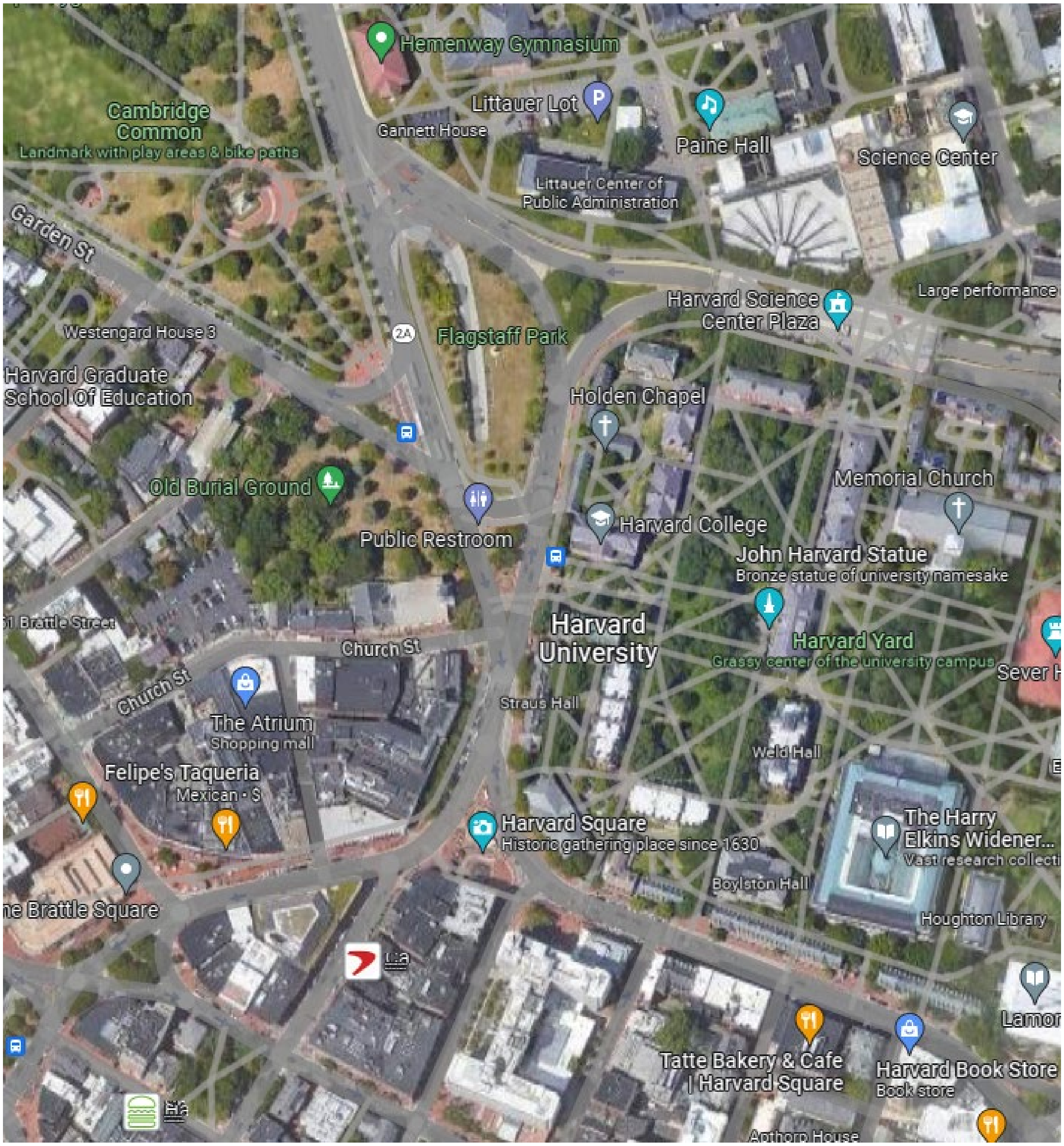

Figure 1. Harvard Square – Intersection in Cambridge

Figure 2. Bowker Overpass and Storrow-Charlesgate Interchange – Interchange in Boston

Part B: Reclaim the Waterfront

Learning Objectives:

- Seeing how other cities have redeveloped problem areas.
- Ensuring that alternatives provide capacity to meet existing demand.

Many US cities are cutoff from local waterfronts by highways. Some cities are taking action to reconnect their populations with those waterfronts. Read the following two articles and skim the city planning document to see what Seattle, WA and Fall River, MA have planned. You can look at the Daily Traffic and Ramp Volumes map for an overview of Boston's Charles River Waterfront, which is currently cut off from the rest of the city by Storrow Drive.

1) Article: Seattle—Alaskan Way Viaduct
2) Article: Fall River—Route 79 Improvements
3) City Planning Document: Fall River Waterfront Urban Renewal Plan
4) Daily Traffic and Ramp Volumes: Storrow Drive

Procedure and Discussion

1) Brainstorm alternate designs for features (transportation-related and otherwise) that could occupy this space along the Charles River. Draw these designs on a screenshot of Storrow Drive. (Hint: Use some of the diagrams from the City Planning Document as a model.) Explain what you designed and why you picked it.
2) Use the Daily Traffic and Ramp Volumes map for Storrow Drive to calculate how many cars are carried by Storrow Drive on an average weekday. (Hint: Start with the traffic volume at the east end of the WB side and add to that number the "On" volumes at each entrance. Repeat for the EB side.)
3) Find the capacity of a) a commuter rail train and b) a heavy rail train (like the Red or Orange Line).
    a. How many additional commuter rail trains would need to run per day to completely replace the car traffic carried by Storrow Drive? (Assume 1 commuter per car).
    b. How many additional heavy rail trains would need to run per day?
4) Why do you think cities built highways along rivers or coastlines to begin with?

Pro-tip: Use the "snip" tool (or the Mac equivalent) to take screenshots and Microsoft Powerpoint to add shapes, outlines, shaded areas, and labels.

Part C: Urban versus Rural Commute

Learning Objectives:

- Different modes are appropriate in different situations.
- A variety of user needs must be met.

You and your friends are planning two trips: one to Faneuil Hall to get an authentic bowl of New England clam chowder, and another to MassMOCA to see the Sol Lewitt and James Turrell exhibits. Your friend just sprained both of their ankles in a horrible soccer accident and has to travel by wheelchair. Your starting point for both trips is CEIS at Wentworth. You want to determine whether it is better to drive or take public transportation.

For each of the two destinations, determine:

1. The steps of each trip a) by car and b) by transit.
2. The length of each trip a) by car and b) by transit.
3. The cost of each trip a) by car and b) by transit.

Be specific about the steps: where would you park and how much would it cost? Are the T stops you need to use wheelchair-accessible?

Appendix B

ENGR 1203
Free-Response Student Feedback Questions

1. Do you feel like this class gave you a good overview of the different subdisciplines of civil engineering? Why or why not?

2. What topics or activities did you feel were unnecessary? What topics or activities do you feel were missing from this class?

3. Which lab activity was your favorite? Why?

4. Which lab activity was your least favorite? Why?

5. What would you change about this class and why?

Student Responses

1. Do you feel like this class gave you a good overview of the different subdisciplines of civil engineering? Why or why not? (20 responses out of 29 survey respondents)

- Yes every week we touched on a different area of civil engineering and learned, discussed, and worked on different scenarios where we applied the practices of each subdiscipline
- Yes, the various projects felt relevant to their specific field.
- Absolutely, we covered everything and in a precise clear way.
- I think it did. It helped me understand some of the many issues needing fixing and who engineering processes lead to results.
- Yes I do. Since he was in structural engineering he would always share is perspective on structural engineering and what he would do on a daily before he became a professor. He would also give us a good understanding on other disciplines and would refer us to someone that would know more about the other disciplines if he was unable to answer any question we had.
- Yes, I was exposed to different fields and lab procedures for Civil Engineering which was interesting for me to see all the different things you can do as a Civil Engineer.
- Yes it made me understand the different sub disciplines and figure out which was for me.
- I feel like this really did give me a good understanding of civil engineering and what will be expected of me in the future.

- Yes, this class gave us a good overview of how broad civil engineering can be. There are many subdiscipline, and with each week we learned more about the ones presented in the course.
- yes! each lab covered a different kind of civil and i gained a solid idea of what each one entails in some of its coolest applications
- Yes it covered many different areas
- Yes I do believe this gave me a good overview. It helped me narrow down a focus in civil engineering.
- Yes, we covered majority of the main civil engineering subdisciplines in lab and lecture.
- yes!! we did hands on projects where we got to experience what each type of engineer does giving me a better understanding of what ill be doing in the future
- Yes because most of the projects were almost all hands on and help with our critical thinking skills.
- Yes, this class gave me a good idea of what each subdiscipline does in civil engineering. Which also makes my intended target discipline clearer.
- Yes I do. Lead Author tied in each assignment we had with each subdiscipline we worked on.
- Yes because I got to work with my classmates.
- It gave a good overview since each project focused on a different sector of CIVE and involved more physical/hands-on work than calculation work.
- Yes, I feel like it gave me a good overview of different subdiciplines because before this class I didn't really know about them. I knew it was a thing but nothing about it.

2. What topics or activities did you feel were unnecessary? What topics or activities do you feel were missing from this class? (19 responses out of 29 survey respondents)

- I feel like it was all important in their own ways.
- NA
- I feel like all the topics were necessary and well taught.
- I feel that every topic was necessary because they all connected.
- I didn't feel anything was unnecessary, but I think the class could be longer to get more in depth.
- I thought everything was important and everything was covered.
- The spring constant lab didn't feel relevant. Labs that were completely computer based defeated the purpose of the lab.
- There was no wasteful activity everything was important and applied to the class

- I think that the only thing we didn't really talk about was what an environmental subdiscipline would be like. Everything else in the course felt like it was necessary or taught something useful.
- Unsure
- Nope
- I thought every topic was necessary for civil engineering.
- I don't think any activities were unnecessary because they all had to do very closely to civil engineering as a general topic.
- none
- nothing perfect class
- N/A
- I feel like this class covered everything.
- i love lab classes, and this one was nothing but fun! we build sand castles, mixes chemicals in dirty water, and built sketti bridges! but at the same time it was introducing us all to some of the core ideas and principles of civil and engineering as a whole. I think a geotechnic lab with soil and foundation underwater to support an embedded structures would be interesting
- For an introduction to engineering, I thought the class was great. A lot of the students had no specific discipline, but with this class it helped them understand and choose some options for the future.

3. Which lab activity was your favorite? Why? (21 responses out of 29 survey respondents)

- The pasta bridge, very fun and made us apply ourselves
- The spaghetti bridge was my favorite activity because it involved creating and testing a final product.
- Spaghetti lab
- The spaghetti bridge lab. I put the most time and effort into it while enjoying building a feasible final project.
- My favorite one was the drinking water treatment.This was my favorite because I liked all the machines and different tools we were using. I also love the pasta bridge activity that we are currently doing.
- My favorite was building the spaghetti bridge. It challenged us to put something together on our own.
- The spaghetti bridge. Interesting project to work on in terms of understanding bridge design and applying it in a testing sense.
- The spaghetti bridge. It was fun to build and design something.
- I honestly liked all of the labs.

- The spaghetti bridge was very fun. The way everyone worked together to engineer something with a common end goal was a great feeling. It showed us how it can be in the future.
- éooooooh, tough choice. I really like playing with sand. i learned a lot in that lab about how soil forces work - seeing it actually done out is a lot more impactful for me than reading it on paper or watching a video. The bridge was also a fun lab. it took a lot of collaboration and it was interesting to see the fail point of each bridge - what worked and what didnt.
- I really enjoyed the spaghetti bridge project and the structural analysis project.
- Reinforced earth or even flocculation was super interesting
- Spaghetti bridge
- I really liked the foam bridge activity
- The spaghetti lab
- My favorite lab was the engineered sand one or the foam beam lab because my group did good on those ones.
- I liked making the spaghetti bridge because it was fun seeing our designs come ot life.
- Lab 4 when we have to work with our group about foams.
- My favorite lab activity was the pasta bridge project given the group coordination and hands-on experience it provides.
- My favorite lab was the reinforced earth lab. Not only was it fun, but it taught me a lot about how much reinforcement actually does.

4. Which lab activity was your least favorite? Why? (19 responses out of 29 survey respondents)

- I liked all of them.
- The water treatment, not interested.
- The transportation Lab was my least favorite because it had a lot of different sections, so it was hard to get the main idea.
- My least favorite was the topography lab. This was my least favorite because I think it was just too much for someone who has never learned about topography before.
- I don't think I have a least favorite.
- water lab it just took too long and i didn't get much out of them
- The lifecycle analysis lab because it wasn't hands-on.
- My least favorite lab activity was probably the spring constant because I had done something similar to that in my physics class and my engineering class in high school, but I understand that not everyone took the same courses as me so other people probably didn't do something like that before.
- The topography lab since it was mostly filling out a sheet and making really rough calculations.
- Nothing
- I didn't like the topographic map activity because it was hard to understand some of the questions being asked.
- The elevation and topography lab was definitely my least favorite lab because it was the most intriqite lab that required lots of paying attention to tiny details. Also, the fact that it was all on paper was pretty annoying.
- probably the water filterer
- was not a huge fan of the topography activity.
- Transporation lab
- Topography because it was paper work.
- My least favorite was the transportation lab because I am not extremely interested in that field.
- ironically (as a transportation concentration major) i disliked the transportation lab the most. specifically, part c which involved Profanity amount of research and comparing and digging for what was the most efficient was actually going to work.
- The topography lab. I just don't like topography in general.

5. What would you change about this class and why? (17 responses out of 29 survey respondents)

- I would make it project/challenge based so that students can learn by doing, work in teams, and engage more deeply into the work.
- Nothing
- Nothing Lead Author did a great job
- A little longer, either more classes a week or a follow up course to the class.
- I would not change anything about this class
- I would keep it the same, great introduction course.
- I don't see any reason to change it.

- its very team based - every single lab was done as a group. maybe throw in one things that's individual to weed out the slackers lol
- I wouldn't change anything, I think it gave students a good chance to learn about the different disciplines in civil engineering.
- Not much, pretty awesome class
- absolutely nothing
- honestly nothing
- Nothing really.
- I wouldn't change anything really.
- Nothing
- Have more projects involving the assembly of materials like the bridge lab.
- I like this class and the way that it is structured. I think that it was fine the way it is and nothing I can think of should be changed. Good for an introduction class.

General Comments (12 responses out of 29 survey respondents)

- I love how each project we worked on had an interactive group portion.
- The course was really fun and interesting, and you did a very good job in engaging the class to one another, which made it an even better learning experience. I hope I can have class with you again soon.
- GREAT PROFESSOR taught the course in the best way possible and helped me understand the work well.
- The bestest teacher ever this was my favorite class this year, ive learned a lot and made a lot of fond memories.
- Really good guy
- Lead Author provided a healthy learning environment and allowed students to learn and apply skills appropriately. We learned all different forms of material and he really wanted to ensure that we not only understood the content but knew how to apply it to everyday issues.
- Amazing professor, very knowledgeable and very interactive with students.
- top tier. I love how casual you are, how you spoke like it was just a conversion during an office hour; which allowed for a super-low stress environment which allowed me to produce my best work and just really enjoy my time and the labs themselves. 10/10, pls come back
- Lead Author was by far one of the best professors I've had. He is extremely knowledgeable in his line of work, and the way that he teaches the subject makes it easier to understand. He found ways to keep us engaged, while also being focused on what we needed to get done. Talking to him is easy, and he always makes sure to help if asked for additional help. It was a pleasure being one of his students, and I hope I can have him again in the future.

- Lead Author was an awesome teacher. He really explained all the content well and he always related it to something in real life that most of us knew. He would also tell us much about his experiences in Structural Engineering which is helpful because it shows us what we might be getting into in the future. He would also take time to answer any questions or concerns that we had and would make sure that we got the help or answers that we needs ASAP. Overall, I think that he was is an awesome Professor and I would for sure love to take another course with him in the future.
- Lead Author was one of the best professors I've ever had. He was fun, relatable, and a great educator. 10/10 would recommend this professor to anyone.
- He was a great teacher made me excited about the class always had great activities and overall made me enjoy my first semester in college