Case Study of Integrating Standards, Codes, and Specifications into Engineering Curricula: Various Pathways to Professional Readiness

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Abstract
For professional engineers, understanding and applying standards, codes, and specifications is essential for career success and closely aligns with ABET student outcomes, which support the program's educational objectives to prepare graduates for professional engineering practice. However, a significant gap exists in how engineering faculty systematically integrate the teaching of these concepts into the curriculum. This pilot study at the University of South Alabama aims to address this gap by utilizing Bloom's learning framework to design learning modules that can be incorporated into existing civil engineering courses. These modules span various levels, including an introductory freshman course, sophomore-level mechanics of materials, junior-level civil engineering materials, and senior/graduate-level advanced transportation materials. Activities such as blueprint reading, beam design projects, guest lectures, special homework, and field trips are tailored to the course level. The study also evaluates students' perspectives and demonstrates the effectiveness of these modules in enhancing their understanding, engagement, and retention. The results of this pilot study are expected to be of interest to other institutions and faculty seeking to systematically integrate standards, specifications, and codes into their courses to better prepare students for professional practice.
Keywords: Civil engineering education, standards, codes, specifications, experiential learning, curriculum development

1. Introduction

According to the International Organization for Standardization (ISO), "standards are the distilled wisdom of people with expertise in their subject matter and who know the needs of the organizations they represent—people such as manufacturers, sellers, buyers, customers, trade associations, users, or regulators" [1]. Similarly, Thompson defines standards as an agreed way of doing something consistently to ensure safety and quality [2]. Codes, on the other hand, are sets of guidelines that define standards for the planning, construction, and maintenance of structures. These are typically categorized into safety standards and product standards [3]. Specifications provide detailed requirements for components, products, systems, and services, ensuring they meet the necessary levels of performance and quality [4]. When integrated, design regulations, standards, and specifications form a comprehensive framework that ensures the safe, efficient, and high-quality construction of buildings and infrastructure. These guidelines also promote sustainability and energy efficiency, helping to create structures that are durable, cost-effective, and tailored to the needs of occupants [5].

The development of standards, codes, and specifications has a rich history rooted in the necessity to ensure accountability and safety in construction. One of the earliest known examples is the Code of Hammurabi in ancient Babylon, which established strict rules holding builders accountable for their work, even imposing severe penalties for failures [6]. During the Middle Ages, professional guilds established regulations akin to codes of ethics, ensuring the quality of construction and penalizing breaches with financial loss or expulsion from the guild [7]. The term "civil engineer" emerged in the 18th century, distinguishing engineers working on civilian infrastructure from military projects. With the formal establishment of engineering societies such as the American Society of Civil Engineers (ASCE) in 1852, efforts to standardize practices gained momentum, culminating in the formation of key organizations like ASTM International (1898), AASHTO (1914), and NIST (1901) [8].

Standards, specifications, and codes are typically developed in response to identified needs arising from industry requirements, legal modifications, or technological advancements. The process begins with a draft prepared by a committee comprising specialists and relevant stakeholders, who ensure safety and best practices are prioritized. A thorough review process is then conducted to achieve consensus among interested parties. Once finalized, the standardization body publishes the approved version and makes it accessible to governments, businesses, and other organizations, ensuring an open and inclusive development process [9, 10]. However, this process is either not well covered or rarely taught in most engineering courses, leaving a critical gap in engineering education.

Engineering societies recognize the importance of standards in America's workforce development and the need for engineers to be more involved in standards development [11, 12]. As a professional engineer, standards, specifications, and codes are critically important. However, it appears that students often lack sufficient exposure to these concepts or miss opportunities to learn about them systematically within engineering departments or colleges. Although many faculty members recognize their importance—especially since students are required to use these codes to design projects—there is often no comprehensive approach to integrating them into the curriculum. Furthermore, the significance of these standards in a professional engineer's career is not effectively emphasized at the college level. Consequently, there is a missed opportunity to systematically incorporate education on standards, specifications, and codes into engineering curricula at the departmental level.

To address this gap, a study was conducted in the Department of Civil, Coastal, and Environmental Engineering at the University of South Alabama in the United States. The study explored a systematic approach to designing and incorporating education on standards, codes, and specifications into the curriculum. The research included participants ranging from freshmen to graduate students, who took part in the survey. The project objective is to improve the competency of civil engineering students in understanding documentary standards, standardization, and the process of standards development. This will be accomplished through two key initiatives: (1) creating user-friendly learning modules that are straightforward to implement and accessible to students; and (2) integrating these modules into courses while assessing their impact on student learning outcomes and overall effectiveness.

2. Methodology

2.1 Experiential Learning Model and Bloom's Taxonomy

To achieve the project objective, a multistate and learner-centered approach was designed and implemented, utilizing the experiential learning model (ELM) which emphasizes active engagement and personal experience in the learning process. This model allows students to learn through direct experience and reflection, which has been successfully implemented in higher education and engineering courses to promote critical thinking skills and active learning [13-15].

To ensure that the educational goals and objectives are categorized into a hierarchy of cognitive skills, which is also in compliance with the ABET student's learning outcomes, Bloom's Taxonomy was employed. This framework includes six cognitive skills: knowledge, comprehension, application, analysis, evaluation, and synthesis [16, 17].

Figure 1 presents the ELM model and Bloom's taxonomy, which serve as the foundation for integrating standardization education into civil engineering curricula. The project focuses on developing students' skills in documenting standards, standardization, and standards development, leveraging ELM principles to promote active engagement and personal experience throughout the learning process.

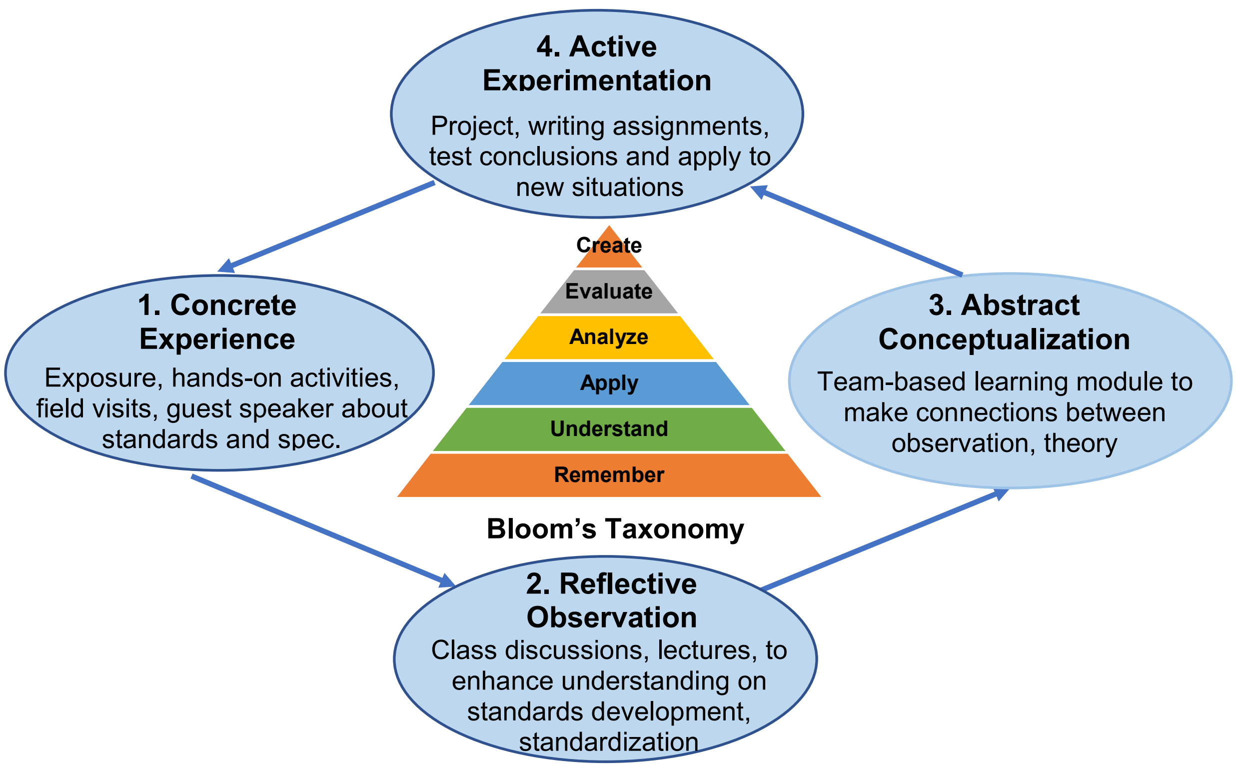


Figure 1. Experiential learning model and Bloom's taxonomy to integrate standardization education into civil engineering curricula.

As illustrated in **Figure 1**, four steps are needed to build an experiential learning model that effectively achieves civil engineering students' learning outcomes in standardization education using Bloom's taxonomy:

(1) Concrete Experience: Providing students with real-world experiences related to standardization and standards development is the first step to get them exposure. For example, experts from standardization bodies or relevant industries are invited to give guest lectures, organize site visits to facilities where standards are implemented, or conduct case studies that involve standardization.

(2) Reflective Observation: After the concrete experience, the designed learning activities will encourage students to reflect on what they learned and observed during the experience. This can be done through class discussions, lectures, or individual reflection exercises.

(3) Abstract Conceptualization: In this stage, students should analyze and conceptualize their observations and experiences, by exploring the relevance and importance of standardization in civil engineering, as well as the benefits and challenges of implementing standards. This can be achieved through class activities such as group discussions, debates, or problem-solving exercises.
(4) Active Experimentation: In the final stage, students should apply their new knowledge to real-world scenarios or problems, such as designing a civil engineering project that adheres to standardization requirements, evaluating the impact of standards on the quality and safety of construction projects, or developing strategies for implementing standardization in construction companies.

2.2 Module Design

Table 1 shows five pilot courses, which span across for freshmen, sophomores, juniors, seniors, and graduate students. A module on standards education has been designed for each course, allowing seamless integration into existing curricula without requiring significant modifications to course content. Notably, this paper focuses on the first three courses (freshman, sophomore, and junior), detailing module design, activities, learning outcomes, and students' perceptions and feedback for these courses. The module design incorporated input from professional engineers, particularly for the field trip activities. The instructor reached out these engineers for considering how to integrate standards and specifications into the field trips, including descriptions, connections to daily life, and the types of standards used in their work. The adjustments to the existing course content are minimal, as our goal is to ensure that instructors feel comfortable and have flexibility in making revisions, in consultation with the department chair and colleagues. For example, for some hands-on experiments, instructors have added an introduction to interpreting specifications and incorporated videos, which will not significantly affect the existing course schedule.

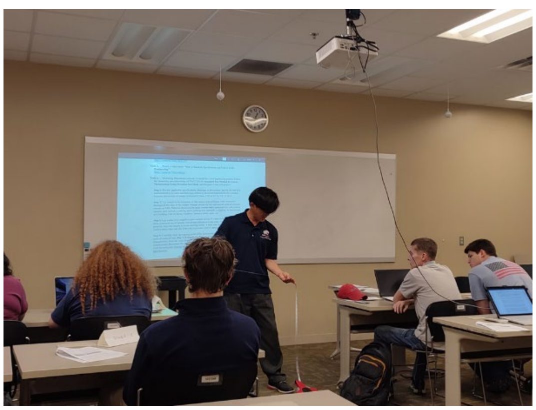
Table 1. Modular Design for Each Course Level

Level	Course Title	Relevance to ELM	Relevance to Bloom's Taxonomy
Freshman	Introduction to Civil Engineering	concrete experience, reflective observation	Remember, Understand, Apply
Sophomore	Mechanics of Materials	concrete experience, reflective observation, active experimentation	Understand, Apply, Analyze, Evaluate
Junior	Civil Engineering Materials and Lab	concrete experience, reflective observation, abstract conceptualization, active experimentation	Understand, Apply, Analyze, Evaluate, Create
Senior	Senior Design I	concrete experience, reflective observation, abstract conceptualization, active experimentation	Apply, Analyze, Evaluate, Create
Graduate	Advanced Characterization of Transportation Materials	concrete experience, reflective observation, abstract conceptualization, active experimentation	Apply, Analyze, Evaluate, Create

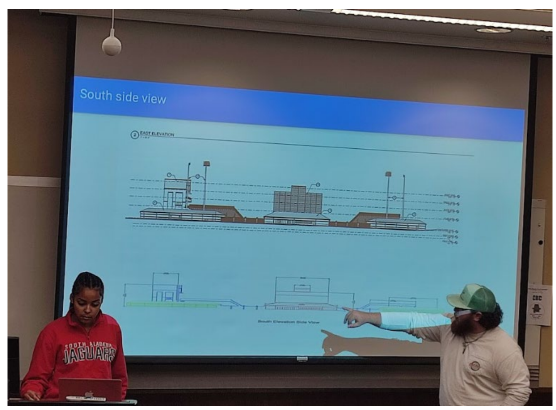
2.2.1 Module Design for Introduction to Civil Engineering Course

For the course of Introduction to Civil Engineering, two instructional videos, “Introducing NIST” and “Introducing Standards, Specifications, and Codes”, were developed as foundational resources to establish a baseline understanding of the role of standards, specifications, and codes in engineering practice. An online quiz was designed and distributed to students to assess their understanding of standards and specification basics, as shown in **Appendix A-1**.

A group project module was also developed to emphasize the practical application of standards through campus-based assignments. Students were introduced to ASTM F2203-13, as shown in **Figure 2(a)** for linear measurements and engaged in a multi-step process: blueprint analysis, site verification of building dimensions, and CAD-based redrawing of blueprints. The module culminated in the production of 3D-printed scaled models and CAD drawings of selected campus structures. Working in groups, students measured and modeled various campus buildings, such as Stanky Field, Shelby Hall, and others. These assignments provided hands-on experience in both digital design and physical modeling techniques. A follow-up quiz with unlimited attempts ensured mastery of the content, allowing students to gain confidence in interpreting and applying engineering standards. **Figure 2(b)** shows one of student groups presenting the blueprint of the south elevation side view of Hancock Whitney Stadium. Additional details of the group project are illustrated in **Appendix A-2**.



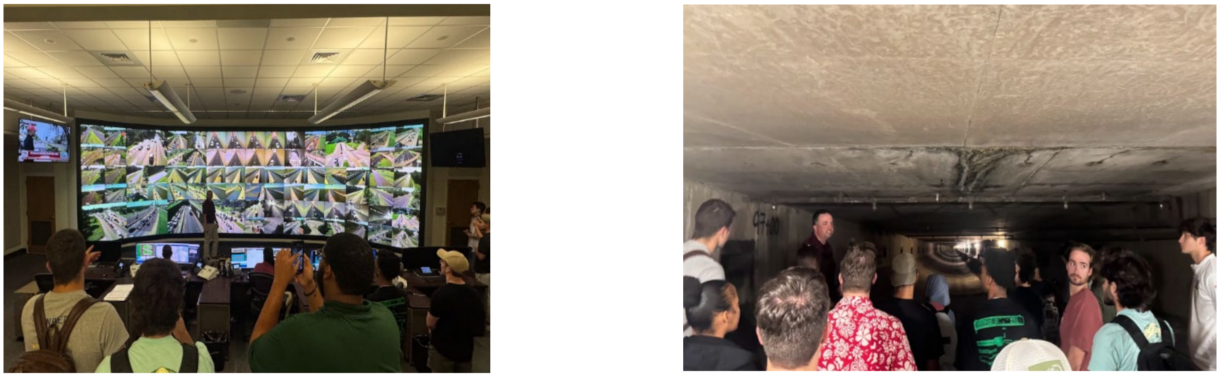
(a)



(b)

Figure 2. (a) In-class illustration of using standardized measurement methods to students; (b) students presented a group project.

A field trip module extended the learning experience beyond campus through a field trip to the Traffic Management Center (TMC) at the Alabama Department of Transportation (ALDOT) and George Wallace Tunnel in Mobile, Alabama shown in **Figures 3(a) and 3(b).** During the visit, students observed real-world applications of civil engineering principles, including traffic flow management, tunnel design, ventilation systems, and emergency response protocols. This experiential learning was supplemented by a group assignment in which students collected data, conducted research, and delivered presentations on topics such as tunnel dimensions, ventilation specifications, and traffic management statistics.



(a) (b)

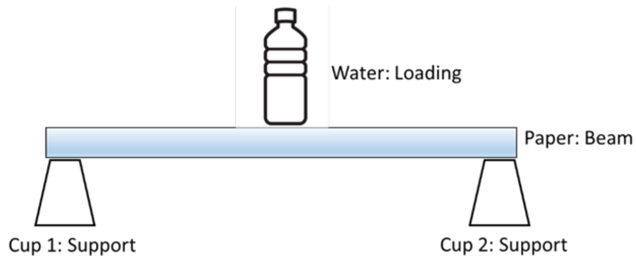
Figure 3. (a) Field trip to visit traffic management center; (b) George Wallace tunnel.

2.2.2 Module Design for Mechanics of Materials

The Mechanics of Materials course module, designed for sophomore students, included a key component: a Beam Design Team Project, which accounted for 15% of the final grade. Students formed teams of up to six members to design a wide-flange beam and document the design process in a technical report. The project tasks included: (1) Drawing shear and moment diagrams; (2) Determining a cost-effective W-beam using the American Institute of Steel Construction (AISC) design database; (3) Calculating principal stresses at the web/flange junction using Mohr's circle; (4) Identifying critical locations that potentially exceed allowable stresses' and (5) Determining the maximum deflection. The project required students to apply AISC standards and specifications for steel beam design. To enhance team spirit and reinforce knowledge, an in-class team-building activity using Kahoot quizzes was conducted. Instructor also provided technical support to the teams during class sessions. Details of the group project are provided in **Appendix B-1**.

An additional in-class activity aimed to give students hands-on experience in understanding beam behavior under loading and factors influencing deflection. Students were divided into small groups and tasked with constructing a simple beam using paper to support a bottle of water (representing the applied load) with two cups acting as supports, as shown in **Figure 4(a)**. Students were asked to collaborate to propose five different approaches to reduce the deflection using available classroom materials. The guideline of this in-class activity is provided in **Appendix B-2**.

One group of students performing the task is shown in **Figure 4(b**). The group's responses revealed a range of creative and practical approaches, reflecting their understanding of fundamental beam behavior principles and factors affecting deflection. This hands-on activity complemented the technical beam design project, providing students with practical experiences in applying standards and specifications.



(a)

(b)

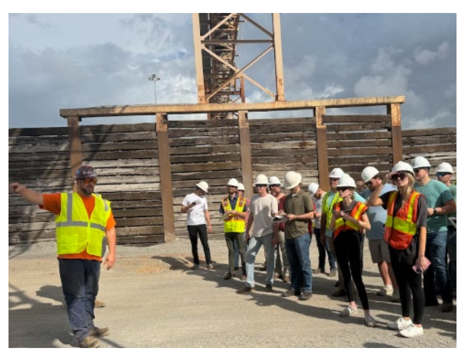
Figure 4. (a) A simply supported beam for an in-class activity; (b) students worked as a group in class discussing the project.

2.2.3 Module Design for Civil Engineering Materials

The Civil Engineering Materials course provides junior-level students with an understanding of various civil engineering materials and their applications. The course combines classroom instruction, field visits, and hands-on laboratory work to equip students with practical knowledge. A key focus was placed on industry standards such as ASTM and AASHTO, with the instructor guiding students through their purpose and practical applications in engineering. To make learning engaging, a Kahoot-based competition and instructional videos were utilized to test and reinforce students' understanding of these concepts.

Field trips played a significant role in connecting classroom knowledge to industrial applications. Students visited Bayou concrete plant, where they learned about concrete production, including the blending of Type 1L cement, coarse and fine aggregates, and the use of admixtures to modify material properties, as shown in **Figure 5(a)**. Another visit to the H.O. Weaver & Sons Asphalt Plant, shown in **Figure 5(b)**, provided insights into asphalt production processes, including the application of Superpave mix design, the incorporation of recycled materials like asphalt shingles, and quality control techniques. These visits allowed students to observe how theoretical concepts are applied in real-world material production. Additionally, students gained valuable experience interacting with on-site engineers and reflected on their learning by writing lab memos documenting the visits. An example of field trip guideline is illustrated in **Appendix C-1**.

(a)



(b)

Figure 5. (a) Field trip to concrete plant; (b) field trip to asphalt plant.

Guest lectures enriched the learning experience by providing valuable industry perspectives. Representatives from the Alabama Asphalt Pavement Association (AAPA) delivered a session on sustainable asphalt practices, emphasizing the use of Reclaimed Asphalt Pavement (RAP), while a speaker from CEMEX highlighted the advantages of concrete pavements. These sessions offered students practical insights into industry standards and demonstrated the real-world applications of classroom knowledge. An example of an online quiz on RAP, based on the guest speaker's presentation, is provided in **Appendix C-2**.

Laboratory activities were a key component of the course. For example, students performed tests on aggregate properties (specific gravity, unit weight, and absorption) and conducted gradation analysis using ASTM and AASHTO standards (**Appendix C-3**). They also worked on concrete mix design, batching, and testing of hardened concrete. A special project focused on green and sustainable asphalt design, where students evaluated additives to improve asphalt binder properties. Experiments on cold-mixed asphalt using 100% RAP allowed students to measure air voids, cracking resistance, and field performance.

The course ended with group presentations (**Appendix C-4**), where students improved their communication skills by sharing their findings through clear and well-organized slides. The goal of the final presentation was to help students build strong communication skills needed for civil engineers by creating and delivering professional PowerPoint slides suited for different audiences. Students chose innovative materials they were interested in as their topics, which allowed them to explore their subject in depth while practicing how to present technical information clearly and professionally.

2.3 Students Perception Survey

For each class, a survey was conducted to capture students' perceptions of the importance of standards and specifications, as well as their understanding of and confidence in applying these concepts to practical civil engineering tasks. The survey included questions on students' familiarity with key organizations (e.g., ASTM, AASHTO, and ASCE), the process of developing standards, and their confidence in using these standards. In addition, survey questions were designed to assess the effectiveness of the modules in enhancing students' understanding and confidence. These surveys were designed to evaluate the feasibility of the integrated learning approach in bridging the gap between theoretical knowledge and practical application.

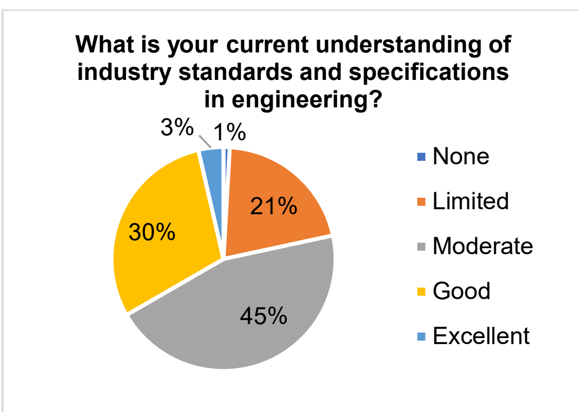
3. Results and Discussions

A post-survey was conducted with 123 students from Fall 2023 to Fall 2024 semesters to evaluate their perceptions of civil engineering standards, codes, and specifications following the implementation of learning modules. The participants included 13 freshmen, 27 sophomores, 47 juniors, and 36 seniors or graduate students. The survey aimed to gather insights into students' attitudes, confidence, and experiences with standards through a mix of question types. Five open-ended questions explored challenges, recommendations, and personal experiences, while nine rating-scale questions assessed confidence levels, perceptions, and the importance of codes. Three checkbox questions collected insights on recognized organizations, concerns, and suggested actions, and four single-response questions focused on exposure, resource use, and familiarity with code development. Additional questions examined the significance of code proficiency in hiring, the consequences of neglecting standards, interest in elective courses on major codes, and international students' perspectives on standards in their home countries compared to the U.S. This comprehensive survey provided valuable insights into the importance of standards in civil engineering education and professional preparation. The results were analyzed using Excel and presented as percentage responses, following a methodology similar to that employed in the study by [18].

3.1 Insights into Student Understanding and Confidence

An analysis of civil engineering students' understanding of and confidence in industry standards and specifications highlights their clear recognition of the importance of these concepts. The provided survey results summarize participants' knowledge and confidence in applying these standards and specifications in engineering practice.

The data presented in **Figure 6(a)** indicate a solid foundation among students in understanding industry standards and specifications in engineering. A majority of students (45%) reported a "Moderate" understanding, 30% described their knowledge as "Good," and 3% rated it as "Excellent." Similarly, as shown in **Figure 6(b)**, confidence levels in applying these standards to real-world engineering problems are also promising. Most students (35%) reported feeling "Moderately confident," 33% described themselves as "Confident," and 5% considered themselves "Extremely confident." These results suggest that the instructional modules and hands-on experiences have been highly effective in building both students' understanding and confidence in key areas of civil engineering practice.



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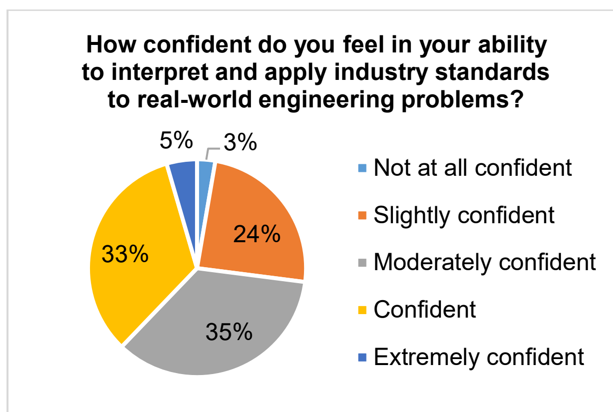


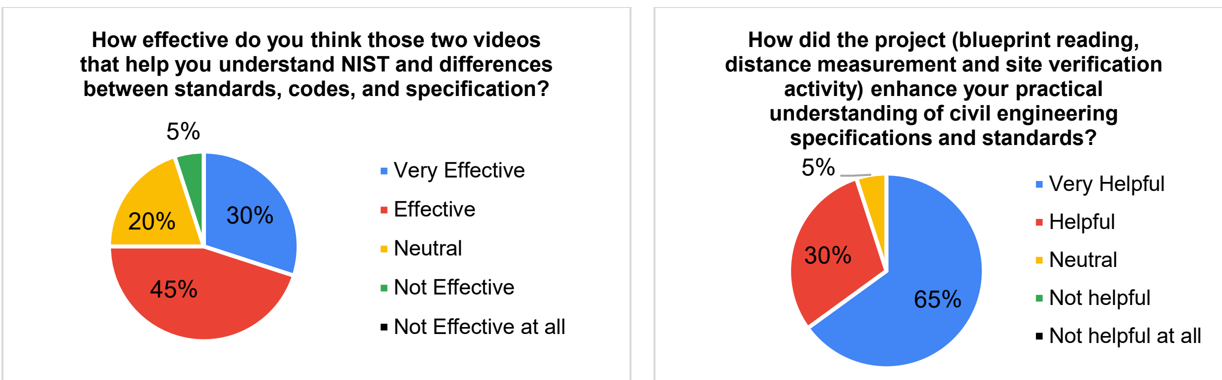
(b)

Figure 6. Students' perception survey results of: (a) understanding of industry standards and specifications in engineering; (b) confidence in the ability to use standards

3.2 Effectiveness of the Modules for the Introduction to Civil Engineering Course

Surveys were conducted to gather student perceptions and assess the effectiveness of various instructional methods in enhancing their understanding of civil engineering standards and specifications. The first survey was administered following a field trip to capture students' perceptions of the experience. The second survey was for evaluating the effectiveness of two instructional videos shown in class. Lastly, the third survey was to assess the usefulness of project activities—such as blueprint reading, distance measurement, and site verification—in improving students' practical understanding of civil engineering standards and specifications.

The data presented in **Figures 7(a)** and **7(b)** highlight the positive impact of instructional materials and hands-on project activities on enhancing students' understanding of civil engineering standards and specifications. As shown in **Figure 7(a)**, the majority of students found the instructional videos to be either "Very Effective" (30%) or "Effective" (45%) in explaining NIST and clarifying the differences between standards, codes, and specifications. Similarly, **Figure 7(b)** indicates that the hands-on project activities were highly beneficial, with 65% of students rating them as "Very Helpful" and an additional 30% as "Helpful." These results emphasize the effectiveness of combining multimedia resources with practical exercises to deepen students' learning and application of engineering concepts.

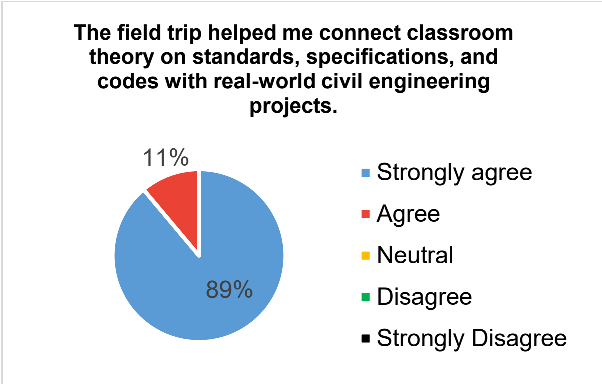


(a) (b)

Figure 7. Effectiveness of: (a) Instructional videos for understanding NIST and standards; (b) Hands-on activities for practical application of engineering standards

A survey was conducted to gather students' perceptions about the field trip and its impact on their learning experience. As shown in **Figure 8(a)**, 89% of students "Strongly Agree" that the field trip helped them connect classroom theory on standards, specifications, and codes to real-world civil engineering projects, while an additional 11% "Agree." Similarly, as shown in **Figure 8(b)**, 67% of students "Strongly Agree" and 22% "Agree" that they are likely to apply the knowledge gained during the field trip in future coursework or projects. These results highlight the effectiveness of the field trip in reinforcing theoretical knowledge through practical exposure, showcasing its value as an experiential learning tool in civil engineering education.

Furthermore, students were asked to include their learning experiences in one of the slides of their group project presentations. Most groups reported feeling significantly more experienced in using CAD software (e.g., MicroStation) and better prepared for future CAD drawing tasks. They also highlighted the importance of time management and collaboration, especially when working with team members with diverse personalities. Additionally, students noted noticeable improvements in their problem-solving skills throughout the group project.



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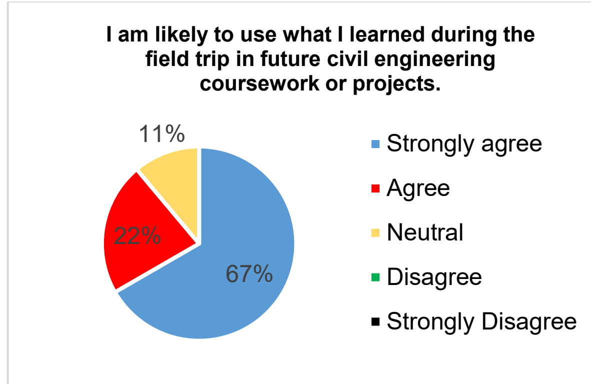

(b)

Figure 8. Field trip effectiveness: (a) Real-world application (b) Future use

3.3 Effectiveness of the Modules for the Mechanics of Materials Course

A question was asked to determine how the beam design project (using the AISC Spreadsheet) enhanced students' practical understanding of civil engineering specifications and standards in the class. **Figure 9** illustrates students' perceptions of the beam design project, which utilized the AISC Spreadsheet, in enhancing their practical understanding of civil engineering specifications and standards. A significant majority, 75%, found the project "Helpful," while an additional 21% rated it as "Very Helpful." These results highlight the effectiveness of the beam design project in providing practical insights and reinforcing students' understanding of critical engineering standards. Only 4% of respondents reported a neutral experience, with no students indicating that the project was unhelpful. This feedback underscores the value of integrating spreadsheet-based design tools into the curriculum to strengthen applied learning.

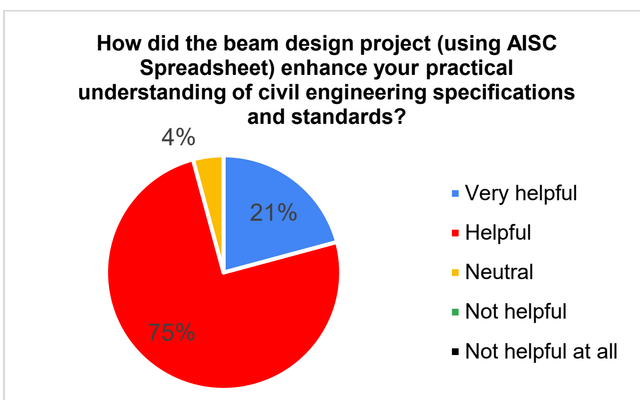

Figure 9. Effectiveness of beam design project.

3.4 Effectiveness of the Modules for Civil Engineering Materials and Lab Course

A survey was conducted to assess the effectiveness of lab activities, field trips, guest speaker lectures, and the final group presentation in enhancing students' practical understanding of civil engineering specifications and standards. **Figure 10(a)** shows that 90% of students found the lab activities using AASHTO and ASTM to be either "Very Helpful" (42%) or "Helpful" (48%), highlighting the effectiveness of hands-on learning. **Figure 10(b)** reflects the impact of field trips to concrete and asphalt plants, with 74% of students rating them as "Very Helpful" (45%) or "Helpful" (29%), demonstrating the value of real-world exposure. In **Figure 10(c)**, 87% of students found guest speaker sessions from industry professionals to be "Very Helpful" (42%) or "Helpful" (45%), showcasing the importance of industry insights. Lastly, **Figure 10(d)** shows that 55% of students rated the final group presentations as "Very Helpful" (13%) or "Helpful" (42%), indicating the benefit of collaborative and applied learning.

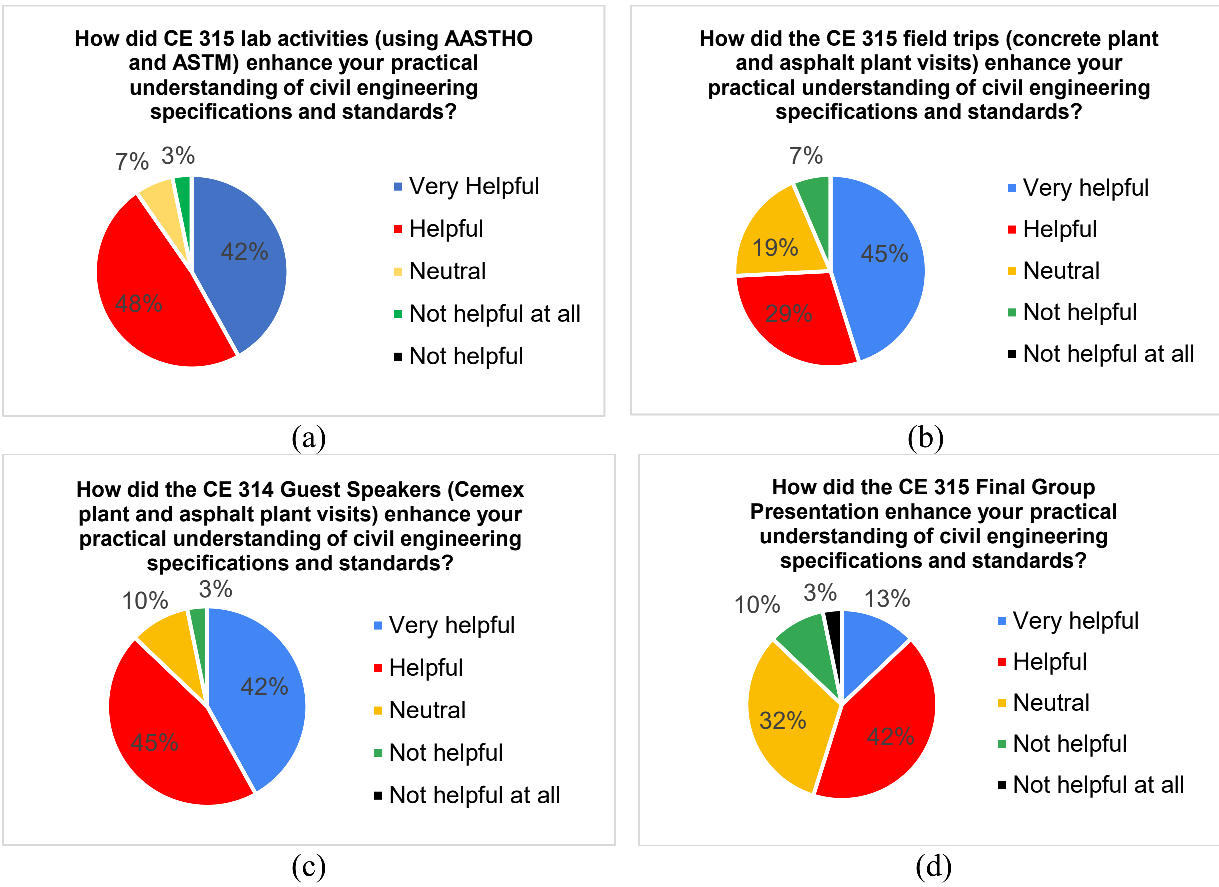

Figure 10. Survey results: (a) Effectiveness of lab activities, (b) Effectiveness of CE 315 field trips, (c) Impact of guest speaker lectures, (d) Evaluation of CE 315 final group presentation.

Overall, the results indicated that lab activities, field trips, and guest speaker lectures were highly effective. The final group presentation demonstrated moderate success. One reason for this is that students selected their own innovative materials as topics, which often lacked established standards or specifications, shifting the focus away from the core objective of understanding and applying these concepts. Additionally, the presentation project did not include evaluation rubrics that emphasized standards and specifications, further limiting its alignment with the course goals. This lack of emphasis on the application of standards likely contributed to the moderate effectiveness of the presentations in achieving the intended learning outcomes.

4. Conclusions

This pilot study employed the experiential learning model and Bloom's taxonomy to design flexible modules that can be seamlessly integrated into the existing civil engineering curriculum. The goal was to enhance students' understanding of standards, specifications, and codes. Based on the study, the key findings are summarized as follows:

- The Introduction to Civil Engineering course effectively introduced students to standards, codes, and specifications through hands-on activities such as blueprint reading, CAD redrawing, 3D modeling, and field trips. These activities bridged the gap between civil engineering theory and practice, with 75% of students reporting that the tasks were "helpful" or "very helpful" in enhancing their understanding and confidence in applying standards.

- In the Mechanics of Materials course, the beam design project guided by AISC standards enhanced students' ability to analyze and design structural components, with 96% reporting improved understanding and confidence in applying standards.

- The Civil Engineering Materials and Lab course provided hands-on experience through ASTM and AASHTO lab tests, field trips to material production plants, and guest lectures, resulting in 90% of students gaining a deeper understanding and practical skills in real-world applications.

Across all three courses, the tailored modules fostered a comprehensive understanding of engineering standards, codes, and specifications, equipping students with essential skills for professional engineering practice. To improve the design of these modules, future studies should incorporate interactive and fun learning approaches, such as gamification and game-based learning and competitions, to foster a sense of engagement and excitement. Structured evaluation rubrics focusing on standards, codes, and specifications can keep students on track while adding elements like team-based challenges or quizzes to promote a healthy sense of competition.

This study has limitations, primarily in its focus on a single institution, which may limit the generalizability of the findings to other universities or broader contexts. Additionally, the long-term impact of the integrated modules on students' career readiness and professional practice was not assessed, leaving gaps in understanding their influence beyond graduation. Furthermore, this paper only provides students' perception survey results, without including evaluation feedback from faculty members, which could have offered a more comprehensive assessment of the modules' effectiveness. Future studies should expand to include multiple institutions to gain broader insights into the effectiveness of standards education across diverse educational settings. Investigating the long-term outcomes of these modules on professional success and workplace engagement with standards would provide valuable evidence for further refinement. Another area for potential improvement is the assessment methodology. This study relies on student perception surveys to evaluate the effectiveness of the interventions. For future study, we will incorporate direct assessment, such as exams and assignment, to measure students' actual proficiency in understanding standards, specifications, and codes.

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Appendix A: Learning Module for the Introduction to Civil Engineering Course

A-1: Quizzes on Standards, Specification Basics

1. What does NIST stand for?
   a. National Institute of Science and Technology
   b. National Institute of Standards and Testing
   c. National Institute of Standards and Technology
   d. National Institute of Scientific Techniques

2) Specifications are detailed technical documents that are the same for all civil engineering projects.
   a. True
   b. False

3) Codes are sets of regulations or rules adopted by governments, regulatory agencies, or professional organizations to ensure public safety, health, and welfare. Codes must be followed by engineers and contractors.
   a. True
   b. False

4) What does ASCE stand for? (Full form)
   a. American Society of Civil Employees
   b. Associated Society of Construction Engineers
   c. American Society of Civil Engineers
   d. Association of Structural and Civil Engineers

5) What does the ASCE 7 standard provide guidelines for?
   a. Minimum design loads for buildings and structures
   b. Construction methods for highways and bridges
   c. Environmental regulations for construction projects
   d. Structural analysis techniques for skyscrapers

6) Why is it important for engineers to follow established standards and codes?

7) Write one difference between standards, codes and specifications?

8) Write one example of Codes, Standards and Specifications?

9) Standards are documents or references established by consensus and approved by a recognized body (e.g., ASCE and AASHTO), providing rules, recommendations, guidelines, or characteristics for common and repeated use in engineering design.
   a. True
   b. False

A-2: Group Project Description

CE 102 Introduction to Civil Engineering

Introducing Standards, Specifications, and Codes in Civil engineering

Purpose:
- **Learn standards, specifications, and codes in civil engineering, and**
- **Understand how to measure the linear dimensions of structural elements**

Standards, specifications, and codes play a vital role in ensuring the safety, quality, legality, and cost-effectiveness of civil engineering projects. They provide engineers with essential guidelines and benchmarks to follow, promoting consistency, interoperability, and compliance across various projects and disciplines within the field of civil engineering.

Instruction: please perform four tasks below

Task 1. Watch a video about "what is National Institute of Standards and Technology (NIST)? What is the difference among standards, specifications, and codes?" https://youtu.be/Mfm_iID4_Pw

Task 2. Watch a video about "What is Standard, Specification, and Code in **Civil Engineering**?"

https://youtu.be/7iDxzv6IGgs

Task 3. Measuring dimensions correctly is crucial for a civil engineering project. Follow the measuring procedure from ASTM F2203-13: **Standard Test Method for Linear Measurement Using Precision Steel Rule**, and integrate it into your project.

Step 1: Review applicable specifications, drawings, or procedures. Specify the unit of a measurement to be used and directions related to precision requirements (for example, measure dimensions of sample to nearest 0.5 mm, 1/32 in, 0.1 in, 0.01 ft, etc.).

Step 2: Lay sample to be measured on flat surface with sufficient color contrast to distinguish the edge of the sample. Sample should lay flat and smooth without wrinkles, creases or folds. Material should not be under tension when measured. For your project, samples may include a parking space, parking lots, sidewalk, a roadway, an intersection, or a building with its floors, windows, entrance doors, stairs, etc.

Step 3: Lay a ruler over sample or place sample on top of a ruler so that the characteristic to be measured can be clearly viewed and referenced to the ruler. Care should be taken to properly align the sample to avoid skewing errors. A ruler may be set on edge along the surface rather than laid flat if the risk of parallax error is apparent.

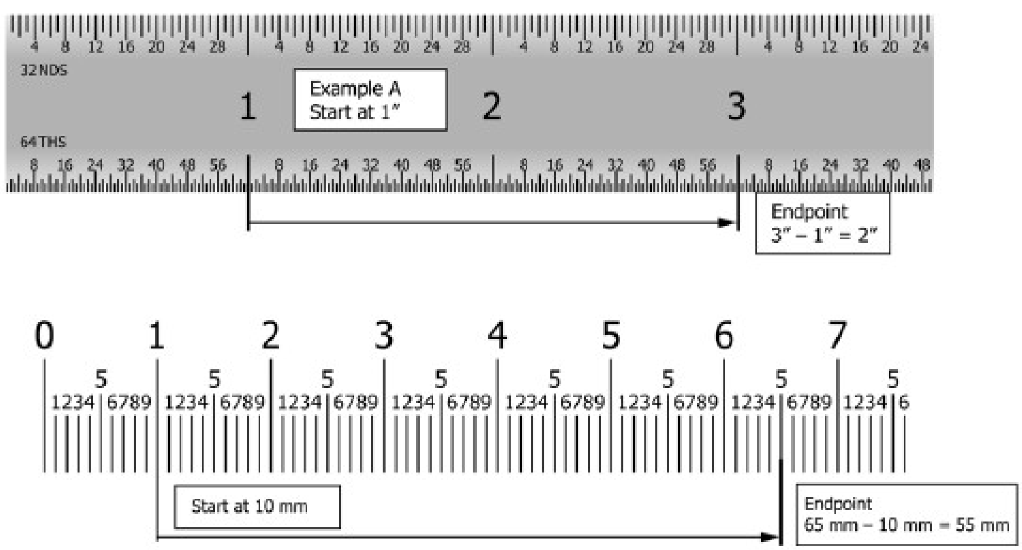
Step 4: Carefully align the starting point of the measurement to the leading edge of fixed scale division on rule (**Fig. 1, Example A**). Then measure to the end point of the characteristic. Note the scale division on the ruler that corresponds to the end point of the measurement. Determine the measurement by subtracting the start point measurement from the end point. Record the number in the unit of measure and precision required by specification.

Note:

When choosing the precision or rounding number for measuring an object, several factors should be considered:

- Accuracy Requirements: Consider how precise the measurements need to be to meet the project goals.
- Instrument Capabilities: Choose a rounding number that aligns with the capabilities of the measuring tools to ensure accurate results.
- Standardization: If there are industry or regulatory standards relevant to the project, follow their guidelines for precision and rounding.
- Practicality: Consider the practical aspects of using the chosen precision. Ensure that it is feasible to measure to the selected level of accuracy consistently throughout the project.
- Team Consensus: If working in a team, discuss and agree upon the rounding number to ensure consistency in measurements and data interpretation.
- Cost: Keep in mind that higher precision measuring tools may come at a higher cost. Balance the required precision with budget constraints.

For your project, you can choose rounding to either 1/32-inch, 0.1 inch, or 0.01 ft. The selection of the rounding number should be agreed upon by the team. The example shown in Fig. 1 rounds to the nearest whole number.



NOTE 1—Example A and Example B begin at the leading edge of fixed scale division on rule at a point within the scale, at 1 in. or 10 mm, for example.

FIG. 1 Proper Alignment to Ruler Scale Divisions

Task 4. In your final project, provide one paragraph to discuss the following:

(1) **How did you measure the dimension throughout your project?**
(2) **What precision (rounding to what number) did you select as a group? Why did you select that precision?**
(3) **How does precision or rounding numbers affecting your project?**

Below is an example:
"For our group project, we adhered to ASTM F2203-13, "ASTM Standard Test Method for Linear Measurement Using Precision Steel Rule", for dimension measurement. Throughout the project, we used tape measures and surveying wheels to measure all objects, including sidewalks and floors, with all measurements recorded in inch, rounding to 0.1 inch. We ensured consistent measurement of structural elements. We chose to round measurements to 0.1 inch based on the capabilities of our measuring tools, consensus within the team, and practicality. Overall, integrating this measurement procedure into my project enhanced my understanding of standards compliance in the civil engineering profession."

Appendix B: Learning Module for the Mechanics of Materials Course

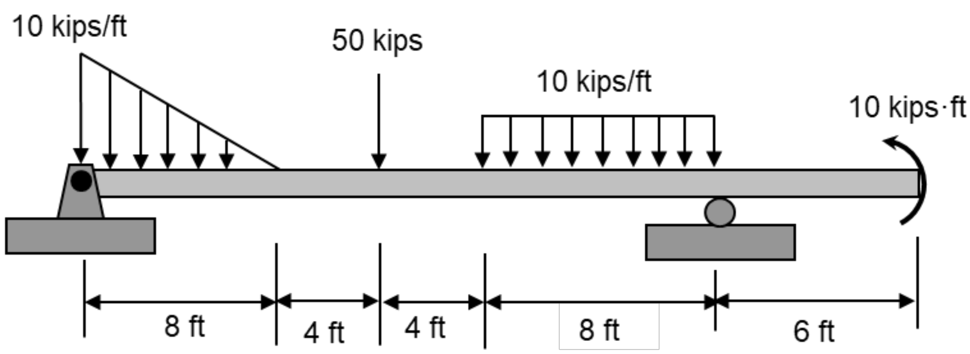
B-1: Beam Design Group Project Using AISC Standard

EG315-101 Mechanics of Materials
Beam Design Project
Due: 11:59 pm Wednesday December 4, (15% of Final Grade)

Background
You have recently commenced your first internship at a renowned engineering firm. Your supervisor has assigned you your first task and is keen to assess the quality of your work on this assignment to evaluate your potential value to the company. You are expected to work with your team members to collaborate on the project.

Your assignment involves forming a team of up to five individuals to collaborate on the project. Once you have assembled your team, please assign each team member a letter (e.g., A, B, C, etc.) on the Google sheet.

Objective
The objective of this assignment is to design a Wide Flange (W) beam to support external loading, as illustrated below. To leave a favorable impression on your supervisor, you must perform a comprehensive beam design by selecting the most effective W beam. Additionally, you must write a technical report that thoroughly justifies your selection and demonstrates your analysis techniques.



Design Assumptions
- Assume the flange and web shapes with dimensions of as listed in the AISC shapes database version 15.0 (See an excel in project folder on Canvas). Material must be A36 Steel (yielding strength = 36 ksi).
- Factor of Safety for the structure must be 2.0 with respect to yielding in tension or compression and 2.5 with respect to yielding in shear.
- Assume the material strength in tension equal to its strength in compression.

Approach and Tasks:
Your integrated approach should include the following tasks:

(1) Draw clear and accurate shear and moment diagram of the beam with maximum values labeled and non-linear curves identified;

(2) Determine W beam that satisfies both normal stress and shear stress requirement;
(3) Determine the principal stresses at the web/flange junction in the middle of span using Mohr's Circle.
(4) Determine the critical locations on the beam where the shear and moment could possibly combine to exceed the allowable stresses. Discuss your results.
(5) Bonus (5 points): Determine the maximum deflection of the beam and its location.

Final Report Requirement and Format

Submit your final report to Canvas. The final report should include the following items with the required order:

a. **Cover Page:** List title of project, team names, course, instructor, and date of submission.

b. **Table of Contents:** List a table of contents with page number indicated. (Check YouTube or Google on how to insert a Table of Contents professionally in a Word file)

c. **Problem statement:** Provide a brief introduction to the problem and background, and state your design assumptions.

d. **General Approach:** A numbered or bulleted list describing the steps you employed to solve for the identified problem.

e. **Analysis and Results:** Analysis and results must include (1) shear and moment diagrams, (2) selection of W-beam; (3) Mohr's circle to determine principal stresses; 4) Combined loadings at critical locations you identified; and possibly (5) deflection (if you pursue bonus points). Figures may be generated by hand on a paper and scanned into your report Word document in a clear and readable format. Scans of sloppy, illegible or incomplete work are unconvincing. A more professional impression can be achieved by producing the figures in Word, PowerPoint, AutoCAD, or other software if appropriate, and formatting equations using Equation editor. All figures or tables should be numbered and called out in the text. For example, Figure 1 shows the shear and moment diagram for the beam.

f. **Conclusion:** Provide a summary of the work and conclude your design, as well as recommendation of any improvements.

g. **Reference:** Provide a list of references used in the project.

h. **Appendix:** Include evaluation sheet (see next page).

References

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Last but not least: Enjoy the collaboration with your team as a professional engineer!

EG315-101 Mechanics of Materials 2024 Fall
Beam Design Project
Final Project Evaluation Sheet

Items	**Requirement**	**Maximum Points**	**Points Awarded**
1. Cover Sheet	Included, professional, and accurate	5	
2. Table of Contents	Included, professional, and accurate	5	
3. Problem Statement	Included, professional, and clear	5	
4. Approach	Clear and logic	5	
5. Analysis & Results	Correct shear/moment diagrams	15	
	Correct beam selection for W-beam	15	
	Correct Mohr's circle and principal stress	15	
	Identified locations that possibly exceed allowable stresses	15	
6. Conclusion	Summarize and conclude your design. Demonstrate the use of standards or specifications.	10	
7. References	Included as required	5	
8. Appendix	Included as required	5	
Bonus 1: Determine the maximum deflection and location		5	
Bonus 2: Submission is punctual, professional, neat, clear, and logical; Demonstrated a collaboration and active communication		5	
Total (Possible)		100+10	

Example of Work Split (Modify this table as you see fit)

Work Task	**Person(s) in Charge**
Leading the discussion and communication	
Shear/moment diagrams	
Correct beam selection	
Mohr's circles	
Writing	
Others (…)	

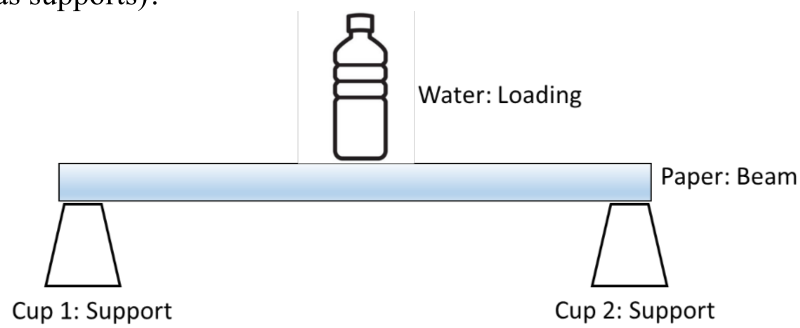
B-2: In-Class Activity of Beam Deflection

Group Number (the same as your project number): ______________

Attendees (Write full name):

____

Work as a group: How can you use the paper as a beam to support a water bottle (as the load) using two cups (as supports)?



Next, consider this: What are effective ways to reduce the deflection of a simply supported beam? Write down five different approaches using the materials provided in class.

Approach 1: ____

Approach 2: ____

Approach 3: ____

Approach 4: ____

Approach 5: ____

Appendix C: Learning Module for Civil Engineering Materials and Lab Course

C-1: Field Trip Guidelines

Hosea O. Weaver and Sons Asphalt Plant Site Visit

Objective:

The lab this week will be a site visit to a local asphalt plant. The objective is to gather real-world information on production of hot mix asphalt and connect the learnt knowledge to the asphalt industry, as well as foster effective communication with engineers. An **individual memo** will be requested to submit to your supervisor, summarizing your observations from the site visit. See last page on what information you would need to collect.

Attire Requirements (Extremely Important!):

- Open-toed shoes, sandals, or "Crocs-type" footwear is prohibited. No shoes with narrow or skinny heels because spike-type heels are easily caught in bar grating.
- Tennis shoes will be fine, but steel toe boots are preferred if you have.
- Wear long pants or jeans. Shorts and skirts are not allowed.
- You may wear sunglasses.
- Hard hat and safety vest will be provided at the site by Dr. Wu. If you have your own hard hat and safety vest, feel free to use yours.
- Failure in following attire requirement will be NOT allowed to enter asphalt plant.

General Guidance:

- The site tour will take 30-40 minutes. Bring a bottle of water if necessary.
- **Time:**

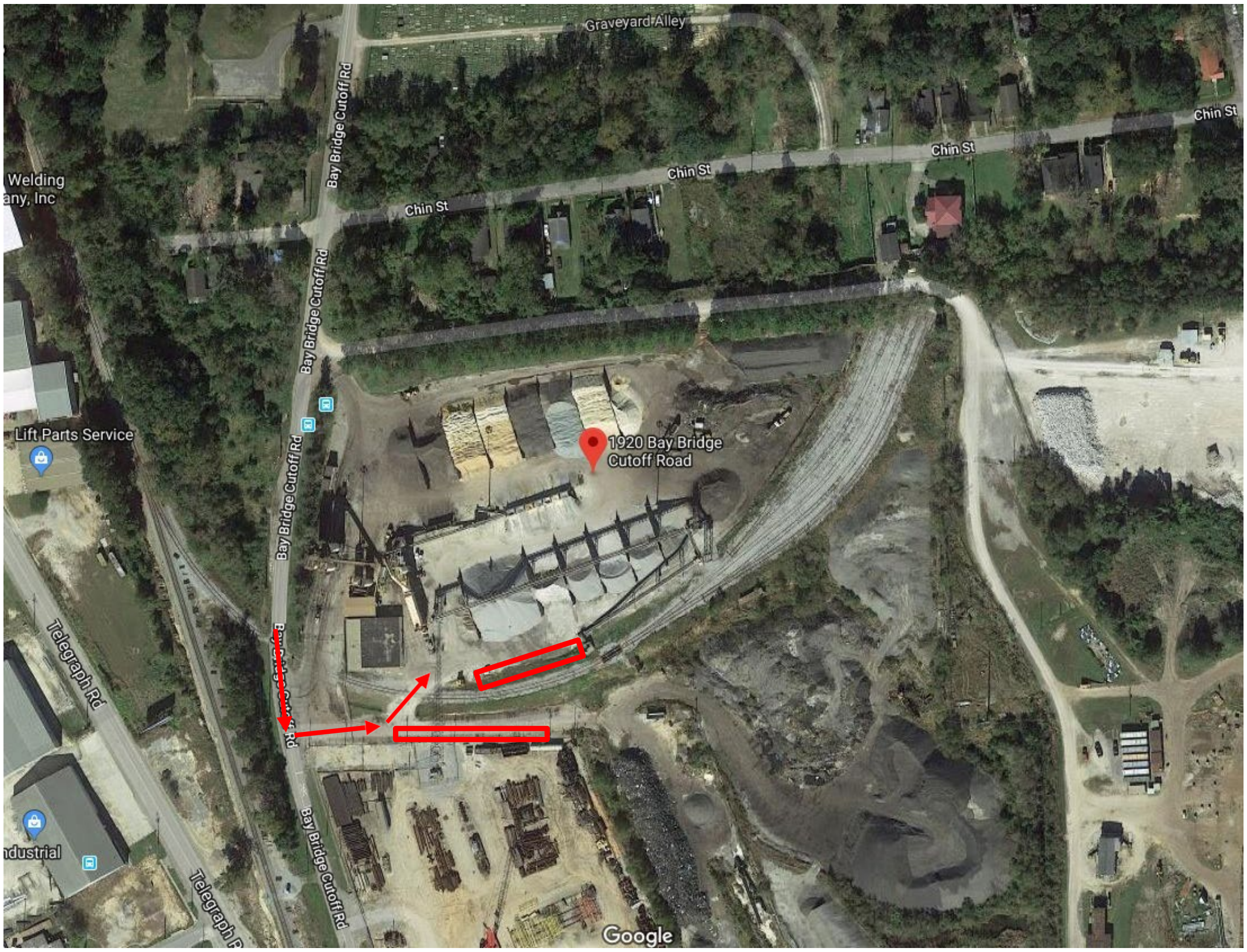
We will ALL meet at the plant at **2 pm on Thursday, October 31**.

- **Address:**

1920 Bay Bridge Cutoff Road, Mobile, AL 36610

- **Directions:**
    - Please make arrangements with your group to carpool if possible. I can provide four seats, please let me know in advance. It will take about 20 minutes (12 miles) to drive there from Shelby Hall, so please schedule sufficient time for driving and considering traffic jam.
    - Park your vehicles at the designated rectangular area close to the railway track or check with engineers where to park. (See the red rectangles on next page's map. Do not block the truck's way.)

Asphalt Plant Map and Parking Lot:



Deliverables:
Prepare a **two-page maximum individual memo** (Appendix does not count page limit), including:

1. Objective
2. In-depth observations during the field visit. See next page about what information you need to collect. (Use your own language to describe. Do not simply answer the questions.) Use professional photos to assist your description.
3. Bonus (See appendix)
4. Conclusions (summarize what you learnt and what fascinated you most)

Evaluation:
Evaluation of memo is based on format and technical contents.

Submission Requirement: Submit a word file to Canvas, due check on Canvas.

Questions: You will need to include answers in a coherent and organized manner in your field memo.

1) How many different types of coarse and fine aggregate are stored (stock piled) on site? What are they?
2) How many asphalt tests are performed at the plant's laboratory? List them all, and describe the machine for performing those tests.
3) What mix design procedure is predominantly used at the plant (Superpave or Marshall)? What is the difference between Marshall and Superpave mix design?
4) What type of asphalt plant did we visit (Batch or drum mix plant or other type)?
5) How many different types of asphalt binders are stored on site? Where stored? What is typical production temperature for each asphalt binder?
6) Do they have polymer modified asphalt binder (PMA)? What is the application for PMA?
7) How much hot mix asphalt (HMA) can the plant produce in one hour? In one day?
8) How much HMA does a typical truck hold? How long does it take for the truck to deliver the mix from the plant to a typical construction site?
9) Who is the in charge of the quality and quantity of asphalt mixture at the plant?
10) Are there any recycled materials used at the plant? What are they? What are the recycled material's percentage in HMA? What are the pros and cons of using such recycled materials?
11) What is the unit price of asphalt binder? What is the unit price of HMA?
12) Do they design and use open-graded friction course (OGFC)? For what type of project? What is targeted air void of OGFC? What is the purpose of OGFC?
13) **Bonus (10 points):** Ask a technical question for engineer, and discuss the answer and your opinion. If you are claiming a bonus, please ensure that you include a section regarding the bonus in your memo.

C-2: Online Quizzes Based on Guest Speaker Presentation

1) Which organization does Mr. Mel Monk work for currently?
- National Asphalt Pavement Association (NAPA)
- National Center for Asphalt Technology (NCAT)
- Alabama Asphalt Pavement Association (AAPA)
- Alabama Department of Transportation (ALDOT)

2) Which fact about asphalt pavement is Incorrect?
- Asphalt pavement is 100% recyclable.
- Over 94% of the nation's highways are surfaced with asphalt.
- Asphalt pavement is No. 1 recycled product in US.
- Asphalt pavement cannot be placed as a perpetual pavement.

3) Which of the following statement is Incorrect about reclaimed asphalt pavement (RAP)?
- RAP has aged asphalt, which is stiffer than virgin asphalt.
- Aggregate in RAP is the same age as virgin aggregate.
- Use of RAP can save materials cost for asphalt pavement.
- The asphalt content in fine RAP is lower than that in coarse RAP.

4) For an asphalt pavement in Alabama, the maximum RAP content in wearing surface course is_____?
- 10%
- 20%
- 35%
- 50%

5) If a contractor chooses to use 100% RAP in an pavement, which of the following location is most appropriate for use?
- Interstate highway
- Low volume road
- High volume road
- Medium volume road

6) Which of the following statement is correct about the use of reclaimed asphalt pavement (RAP)?
- For open-graded friction course, no RAP may be used in asphalt mixture.
- RAP is also called "White Rock".
- Fractionation is not needed for contractor to achieve the uniformity of RAP.
- Adding high content of RAP in asphalt mix will improve low temperature cracking resistance.

C-3: Lab Handout Example: Aggregate Testing

Aggregate Testing: Specific Gravity, Unit Weight (Bulk Density), and Absorption

Problem Statement and Objective:
A contractor has supplied you with samples of coarse and fine aggregate for possible use in a concrete mix. The objective is to determine the necessary parameters for concrete mix design.

Apparatus Required:
Scale, wire basket, water tank, rigid metal container, tamping rod, cone mold, pycnometer, scoop

General Test Procedure:

1. Specific Gravity and Absorption of Coarse Aggregate
    a. Mix aggregate and sample [note that we will not follow the ASTM standard for sampling, but will assume it is representative.]
    b. Immerse aggregate in water for 15 to 19 hours [note that this has been completed]
    c. Remove the specimen from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually.
    d. Weigh the test sample in saturated surface-dry (SSD) condition. Record this SSD weight (B) to nearest 1.0 g.
    e. Immediately place the SSD sample in the wire basket and determine its weight in water at 23 ± 1.7 °C. Take care to remove all entrapped air before weighing it by shaking the container while immersed. Record this submerged weight (C).
    f. Dry the test sample to a constant weight at a temperature of 110 ± 5°C, and weigh it at room temperature, and record this dry weight (A). Note: you will place the sample in the oven and return the next day to determine the dry weight.

2. Specific Gravity and Absorption of Fine Aggregate (Sand)
    a. Fill the pycnometer with water to the mark, and measure the weight (B).
    b. Place 1 kg sand sample in a pan, cover with water, and soak for 15-19 hours [note that this has been completed]
    c. Spread the sample in a pan, and expose it to a gently moving current of warm air by dryer. Stir the sample frequently to obtain uniform drying.
    d. Place the cone mold in a pan and fill with the partially dried sand. Tamp the surface using the tamper for 25 times. Allow the tamper to fall freely each time 0.2" above the top of sample.
    e. Remove the cone and slowly lift the cone vertically. If the sand just collapses, it means that the sample reaches SSD condition. If not, add water or continue drying until SSD condition occurs.
    f. If in SSD condition, immediately weigh out around 500 g of SSD sample, record this SSD weight (S), and introduce into the pycnometer.
    g. Partially fill the flask with water. Roll and agitate the flask to eliminate air bubbles. It normally takes about 15 minutes.
    h. Fill the pycnometer with water to the level, and measure this weight (C).
        i. Carefully pour all sample and water into a pan. Rinse any residue. Oven dry the sample. Weigh and record as dry weight (A). Note: you will place the sample in

the oven and return the next day to determine the dry weight.

3. Bulk Unit Weight and Voids in Aggregate
   a. Determine the volume of the bucket
      i. Fill the bucket with water at room temperature the fullest.
      ii. Determine the mass of the water in the bucket
      iii. Measure the temperature of the water and determine the density as shown below

Temperature		**Density**	
°C	**°F**	**kg/m³**	**lb/ft³**
15.6	60	999.01	62.366
18.3	65	998.54	62.336
21.1	70	997.97	62.301
23.9	75	997.32	62.261
26.7	80	996.59	62.216
29.4	85	995.83	62.166

      iv. Calculate the volume of the bucket by dividing the mass by the density

   b. Use rodding procedure:
      i. Fill the bucket 1/3 full and level the surface with fingers. Rod the layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface.
      ii. Fill the bucket 2/3 full and again level and rod as above.
      iii. Finally, fill the bucket to overflowing and rod again as above.

   c. Level the surface of the aggregate with the rod and determine the net weight of the aggregate.

References:

1. AASHTO Standards posted on Canvas
2. Textbook Appendix Experiment No. 8, No. 9, and No. 10.

Useful Videos Link for Testing:

1. Coarse Aggregate SG: https://www.youtube.com/watch?v=iKUEsPk_Jm4
2. Fine Aggregate SG: https://www.youtube.com/watch?v=Nks_ypn_HBc
3. Coarse aggregate unit weight: https://www.youtube.com/watch?v=N6TKJEeqfd4

Deliverables:

Prepare a **two-page maximum** group memo (See templates on Canvas), including:

1. Objective
2. A brief description of experiment procedure (who, where, when, and how)
3. Test results are organized and legible, including: (1) Coarse Aggregate: bulk specific gravity, dry; Bulk specific gravity, SSD; Apparent specific gravity; Absorption; (2) Fine Aggregate: Bulk specific gravity, dry; Bulk specific gravity, SSD; Apparent specific gravity; Absorption; (3) Bulk unit weight and voids in aggregate bulk.
4. Conclusion
5. Appendix (if any, does not count page limits.)

Submission Requirement: Submit the memo to Canvas. Due: check the deadline on Canvas

Evaluation: Evaluation of memo is based on format and technical contents, using the rubric below.

Criteria	Poor 3 pts	Fair 6 pts	Good 8 pts	Excellent 10 pts
Content & Development (20%)	• Content is incomplete. • Major points are not clear, not persuasive • Equation, figure and table are inappropriate.	• Content is not comprehensive or not persuasive. • Major points are addressed, but not well supported. • Most points required by the assignment are covered. • Content is inconsistent with regard to purpose and clarity of thought. • Equation, figure and table are appropriate.	• Content is somewhat comprehensive, accurate, and persuasive. • Major points are mostly clear and supported. • Most of the points required by the assignment are covered. • Content and purpose of the writing are mostly clear. • Equation, figure and table are almost correct.	• Content is somewhat comprehensive, accurate, and persuasive. • Major points are mostly clear and supported. • Most of the points required by the assignment are covered. • Content and purpose of the writing are mostly clear. • Equation, figure and table are correct and appropriate.
Organization & Structure (20%)	• Organization and structure detract from the message of the writer. • Paragraph is disjointed and lack transition of thoughts.	• Structure of the paragraph is not easy to follow. • Paragraph transitions need improvement.	• Structure of the paragraph is mostly clear and easy to follow.	• Structure of the paragraph clear and easy to follow.
Format (20%)	• Paper lacks many elements of correct formatting. • Paragraph is inadequate in length. • No citation.	• Paper follows some of guidelines. • Paper is under word length. • Citation is inappropriate.	• Paper follows most of designated guidelines. • Paper is the appropriate length as described for the assignment. • Citation is correct.	• Paper follows all the designated guidelines. • Paper is the appropriate length as described for the assignment. • Correction is correct and include all components.
Grammar, Punctuation & Spelling (20%)	• Paper contains numerous grammatical, punctuations, and spelling errors. • Language uses jargon or conversational tone.	• Paper contains few grammatical, punctuations, and spelling errors. • Language lacks clarity or includes the use of some jargon or conversational tone.	• Rules of grammar, usages, and punctuations are mostly followed; spelling is mostly correct. • Language is mostly clear and precise; sentences display good structure.	• Rules of grammar, usages, and punctuations are followed; spelling is correct. • Language is clear and precise; sentences display consistently strong, varied structure.
Conclusion (20%)	• There is a 1-2 sentence that does not include all the necessary elements of a closing paragraph.	• The conclusion is recognizable, but does not tie up several loose ends. • Does not include all the necessary elements of a closing paragraph.	• The conclusion is recognizable and ties up almost all the loose ends including restating the thesis. • Include all the necessary elements of a paragraph.	• The conclusion is strong and leaves the reader satisfied. • The thesis statement is restated. • Sums up the main topic successfully and leaves a potent final statement.

C-4: Final Group Presentation Guidelines

Group Final Presentation Guideline

Learning Objectives: Develop and demonstrate effective communication skills as a civil engineer by creating and delivering professional presentations using well-designed PowerPoint (PPT) slides tailored for various audiences.

Time: All groups will meet at 1:00 pm Thursday, 12/5. Upload your group's PPT to Canvas by 12:30 pm 12/5.

Score: Final Presentation will be 10% of your final score for CE315 course.

Topic Selection: Your group will be assigned a topic related to civil engineering materials. Through thorough research from reliable sources, your group is expected to present detailed information, including the definition, material properties, testing methods, types and applications, cost, and sustainability aspects. If your group wishes to propose a different topic, please consult Dr. Wu for approval first.

- Group 1: Self-healing Concrete
- Group 2: Engineered Wood
- Group 3: 3-D Printed Concrete
- Group 4: High Friction Surface Treatment
- Group 5: Recycled Plastics in Concrete
- Group 6: Recycled Plastics in Asphalt
- Group 7: Polymer Modified Asphalt
- Group 8: Biochar
- Group 9: Carbon Fiber

Requirement: Your presentation will be evaluated by two parts: (1) Technical content and PPT design (50 pts); (2) presentation and Q/A (50 pts). Please read the guideline below.

Technical Content and PPT Design:

Feel free to design your PPT in any style preferred by your group, ensuring a logical arrangement that includes the following items. A presentation of 5-10 slides is appropriate. Examples of PPTs from previous years are posted on Canvas for reference only. Please note that copying from others is strictly prohibited. Below is a recommended slide content:

(1) Title Slide: Include the topic, presenters, department, affiliation, and presentation date.
(2) Provide an overview of your presentation.
(3) Introduction: What is this material? How is it manufactured? What is its application?
(4) Results and Discussions: Present your findings using qualitative and quantitative data. What are the materials properties? How we measure those properties?
(5) Cost information or cost effectiveness: Is the cost reasonable compared to other similar materials? What is the cost benefit?
(6) Sustainability aspect: How does the use of the material take sustainability into consideration?
(7) Summary/Conclusions: summarize the findings, critical analysis, and recommendations.
(8) References: List all references cited.

Note: Use photos, images, and tables where applicable to enhance your presentation. Ensure appropriate use of fonts, images, colors, and white space for a polished appearance.

Presentation:
PPT will be presented as a team. The presentation should be delivered in a clear and logic manner, 5 to 10 min. Each group member should participate the presentation. The presentation will be evaluated by all students, TA and instructor. The evaluation sheet is attached.

Q/A Session:
After the presentation, you will be asked with any questions from audience.

PPT Evaluation Rubrics

Category	**Scoring Criteria**	**Points**	Score
Title	This slide features the title of the presentation and includes the author's name. A graphic or picture is included that relates to the most important concept of the presentation.	5	
Introduction	This slide provides an explanation of the purpose and audience for the presentation.	5	
Results	Technology terms and concepts are properly used. All results including material properties, application, cost, and sustainability are covered.	10	
Conclusion	Provide a clear summary of the topics, along with critical analysis and recommendations.	10	
Slide Composition	Appropriate font, size and each slide can be easily read.	5	
	Figures and table are relevant, fit for purpose and add the impact of the slide.	5	
	Color combination make the information easy to read.	5	
Overall	Professional look	5	
Total (50 maximum)			

Presentation Evaluation Rubrics

Category	**Scoring Criteria**	**Points**	Score
Topic	Presentation contains scientifically accurate material.	10	
Speak	Each speaker uses a clear voice, easily heard.	10	
	Each speaker maintains good eye contact with the audience.	5	
	Each speaker uses proper posture at all times.	5	
Q/A	Demonstrates full knowledge by answering all class questions with explanations and elaboration.	10	
	Answer questions properly and correctly	5	
Overall	Professionalism, wear appropriately.	5	
Total (50 maximum)			