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An Investigation into the Effectiveness of Web-based Pre-Class Reading Responses

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Abstract

Pre-class reading responses were introduced in several courses to address students' lack of understanding, involvement, and preparation. Activities such as reading, videos, or assessments engage students with content before class, enhancing learning. In 2022-23, web-based pre-class reading responses were implemented in Engineering Economy, Mechanics of Materials, and Introduction to Geotechnical Engineering to encourage student preparation. In the experimental sections, students answered two or three conceptual questions on the course website before each class. These responses were used to tailor in-class activities to better address students' needs. This study compares test performance between students who completed these pre-class responses and those who did not, with both groups being taught by the same instructor and following the same learning objectives and assessments. Preliminary results show that the experimental group outperformed their peers on both midterm and final exams. Additionally, a significant positive correlation was found between students' pre-class response scores and their exam performance.

Motivation and Background

An instructor of Engineering Economy, Mechanics of Materials, and Introduction to Geotechnical Engineering has identified concerns such as knowledge gaps, inconsistent participation, lack of preparation, and excessive unexcused absences through assessments and observations. To address these issues, web-based pre-class reading responses were introduced to enhance understanding, engagement, and preparation. This study aimed to enhance student preparedness and engagement through pre-class interaction with course materials while uncovering hidden thought processes to guide the design of skill-focused in-class activities.

Implementation of pre-class pedagogical approaches such as pre-class quizzes and exercises, flipped classrooms, and just-in-time teaching (JiTT) demonstrate positive impacts on student performance, student engagement, conceptual understanding, and long-term retention [1]-[4]. Grounded in cognitive load and constructivist learning theories, these approaches break down complex topics into smaller, manageable 'chunks' while providing a contextualized foundation for learning [5]-[6]. Reduced cognitive load minimizes stress on students and generates a positive environment for student participation on topics already considered [7]. To do this, questions are crafted by the instructor to elucidate knowledge gaps and areas that need to be expanded upon rather than simply asking students what they do not understand [8]. Hence one of the primary features is "student's responses to JiTT questions made gaps in their learning visible … prior to class" [9]. The focus then is on finding "misconceptions" or thinking errors prior to class so that they can then be corrected by the instructor [8].

There are several advantages to this type of pedagogical approach. One significant advantage to pre-class engagement is the identification of student needs prior to classroom discourse. This allows real time content and lesson plan modification by instructors. In addition, it has been shown that using this strategy can lead to more prepared students [9].

Adjusting lesson plans presents several challenges for instructors. These include increased instructor workload and technological issues. Significant time requirements are required for instructors to review pre-class assignments and adjust lessons plans with limited time [10]. The increasing use of learning management systems (LMS) enhances evaluation and turnaround time. However, technical issues (i.e., incorporating images, videos, audio, and interactive elements) and student access must be considered. In 2022-23, web-based pre-class reading responses were implemented in Introduction to Geotechnical Engineering, Mechanics of Materials, and Engineering Economy to encourage student preparation.

Course Format

Each course is briefly outlined to provide context for implementing web-based pre-class reading responses. This approach was trialed across various engineering courses to assess its impact on student preparedness and performance.

Introduction to Geotechnical Engineering is a three-credit course which is offered in the fall semester that meets three times a week (50 minutes each). The course focuses on engineering use of soils; laboratory and field determination of soil properties; determination of phase relationships; engineering soil classification; soil-water interaction; stress effects of loading on soils at depth; consolidation, compaction, shear strength, bearing capacity theory, and several special geotechnical topics.

Mechanics of Materials is a three-credit course that meets twice a week (75 minutes each). The main topics of the course include elastic properties of structural materials; internal stresses and strains; principal stresses and strains including Mohr's Circle; axial; torsion; flexure; shear; bolted joints; combined stresses; shear and moment diagrams; and beam deflections. Mechanics of Materials is offered in fall, spring, and summer semesters.

Engineering Economy is a two-credit course that meets twice a week (50 minutes each). The main topics of the course include Time value of money applications; nominal and effective interest rates; capitalized cost; equivalent annual worth for alternative comparison; rate of return analysis for alternative comparison; benefit cost ratio alternative comparison; ethical considerations; depreciation calculations; and breakeven analysis. Engineering Economy is offered in fall, spring, and summer semesters.

Pedagogies Used in Control Sections

The instructor used various active learning techniques in Geotechnical Engineering, Engineering Economy, and Mechanics of Materials, including open-ended, real-world application assignments, case studies, formative assessments, physical models and others. All courses and sections were taught by one individual instructor.

Pre-Class Reading Response Technique Used in Experimental Sections

In fall 2022, Pre-class Reading Response technique was implemented in one section of the Introduction to Geotechnical Engineering and Engineering Economy. Pre-class Reading Response technique was implemented in Mechanics of Materials in Summer 2023. The pre-class reading responses served the function of encouraging students to prepare for class regularly, helping the instructor to identify students' difficulties in time to adjust his lesson plans, and set

the stage for active engagement in the classroom. The instructor began each lesson by summarizing student responses to the pre-class questions and then discussing common errors. The pre-class responses aimed at assessing whether students had completed and understood the concepts presented in the assigned readings. The pre-class reading responses were 8% of the course grade. The timeline for a typical pre-class response assignment is shown in Table 1.

Table 1. Pre-class reading response timeline.

72-48 hours prior to start of class	Pre-class reading response questions were developed.
48 hours prior to the start of class	Pre-class reading response questions were posted on LMS (Canvas).
1 hour prior to the start of class	Submission deadline for the pre-class reading response questions
45 minutes prior to the start of class	Pre-class responses were reviewed.
25 minutes prior to the start of class	Class contents were modified based on students' responses.
10 minutes prior to the start of class	Students' answers to pre-class activity were summarized on the 1-2 PowerPoint slides.
During the first 15 minutes of class	1-2 PowerPoint slides were used as a scaffold for lesson.

The following is a sample pre-class response as seen by the students in the Introduction to Geotechnical Engineering.

Module 2: Pre-class Reading Response #6 Start Assignment

Due Oct 5, 2022 by 4pm **Points** 5 **Submitting** a text entry box or a file upload

Question #1. Two identical building footings with the same load are constructed in different soils: one in medium dense sand, the other in lean over-consolidated clay. Which soil poses a greater long-term settlement risk, and why?

Question #2. Figure 1 shows a footing carrying a structural load (F) and an embankment covering a large area, both applying the same stress on clayey soil at the ground surface. Will the settlement from these two loadings be the same? If not, which will be greater and why?

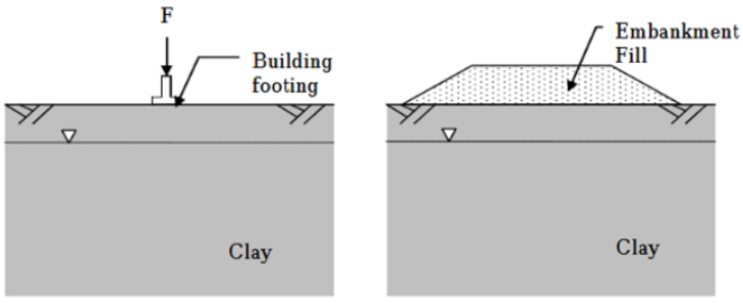

Figure 1. Pre-class response question #2 adapted from [11].

Study Method

The study investigated the extent to which students' preparation for classes and their performance on the exams were affected by pre-class reading responses. Direct assessment data for Introduction to Geotechnical Engineering, Mechanics of Materials, and Engineering Economy included student performance on identical midterm and final exams in both experimental and control sections. The same instructor taught and graded all sections using an established solution and rubric, ensuring consistency in meeting the same learning objectives. The following describes the guiding research question for this study: (1) Do web-based pre-class reading responses lead to measurable improvements in midterm and final exam scores in these engineering courses? (2) Is there a significant correlation between students' performance on pre-class responses and their exam scores?

Figure 2 illustrates the means and the standard errors of the scores on the midterm and final exam for the experimental and controlled sections of both sections of Introduction to Geotechnical Engineering, Mechanics of Materials, and Engineering Economy. The experimental section of the Geotechnical Engineering (mean midterms: 91.2 and 89, final: 86) scored higher than the control section (mean midterms: 83.6 and 82.5, final: 79). Figure 2 indicates similar exam averages for both experimental and control sections of Engineering Economy. Figure 2 highlights that the experimental section of Mechanics of Materials section (mean midterms: 90 and 89, final: 86.7) outperformed the control section (mean midterms: 85 and 84, final: 80) by about 5%.

A two-sample t-test was conducted to determine if there was a significant difference between experimental and controlled sections. For Introduction to Geotechnical Engineering, the analysis showed a statistically significant improvement in the experimental section ($p < 0.05$ for both midterm and final exams). Similarly, in Mechanics of Materials, the t-test with a significance level of 0.05 revealed a significant difference favoring the experimental section ($p < 0.05$). However, there was no significant difference between the experimental and control sections in Engineering Economy, possibly due to differences in student characteristics.

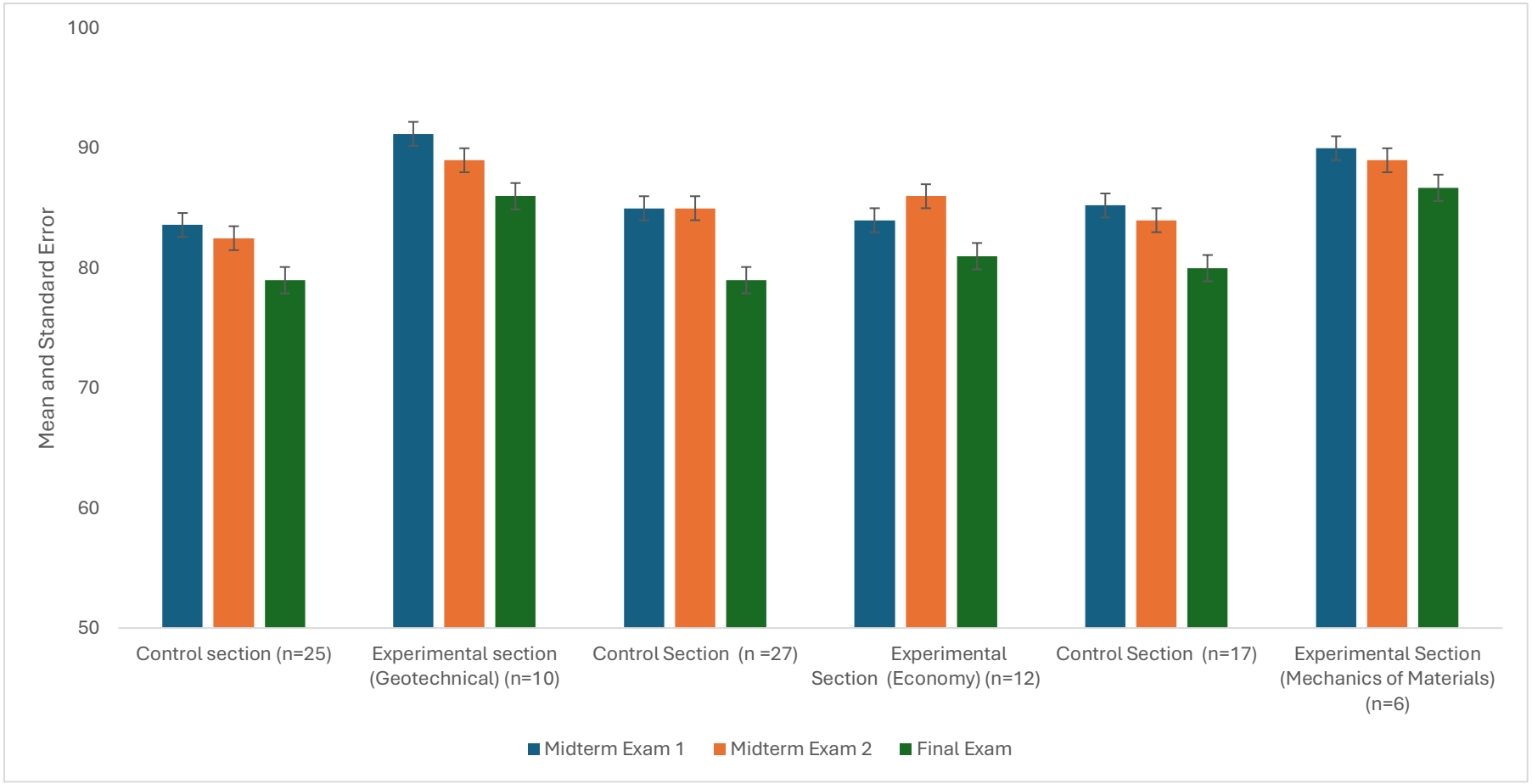

Figure 2. Mean and standard error values for midterm and final exams

The study also found that there was a strong positive correlation between final exam scores and average pre-class response variables in both Introduction to Geotechnical Engineering and Mechanics of Materials ($r = 0.97$, $p = 0.00001$). A scatter plot summarizes the results in Introduction to Geotechnical Engineering (figure 3). The increase in scores obtained on the pre-class responses was correlated with the increase in scores on the final exam. The correlation is significant at the 0.05 level.

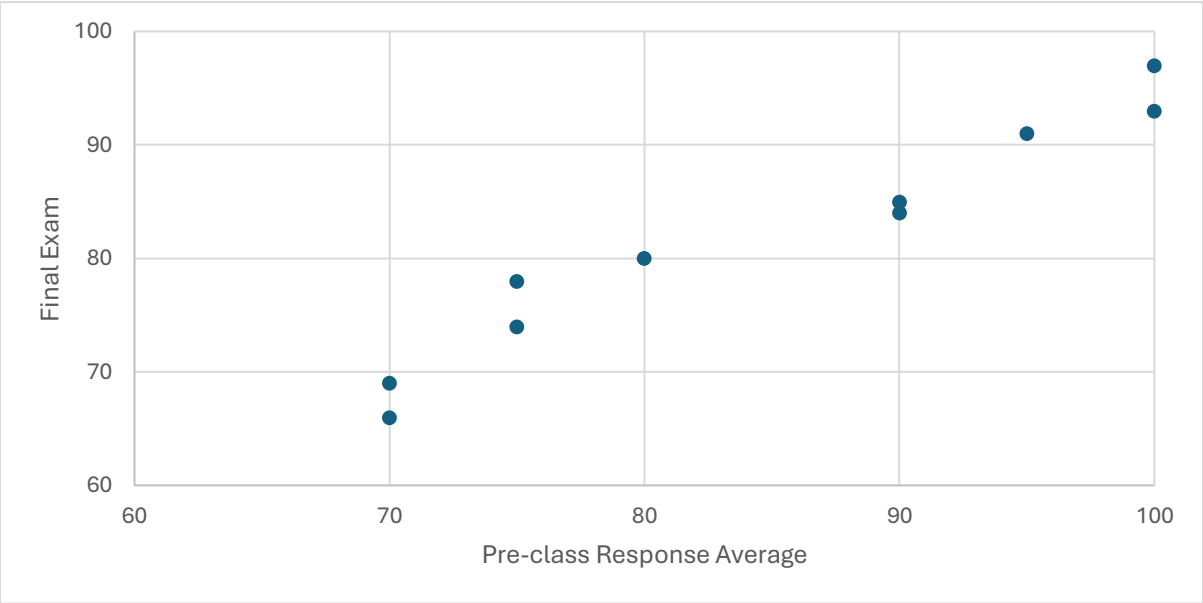

Figure 3. Scatter plot of final exam scores vs. pre-class response in Geotechnical Engineering

Conclusions

In 2022-2023, an instructor utilized pre-class reading response techniques in three different courses. The effectiveness of this technique was evaluated by comparing the summative assessment results of control and experimental sections. While the differences between experimental and control sections were not statistically significant in Engineering Economy, they were significant in Introduction to Geotechnical Engineering and Mechanics of Materials. It was also determined that a significant positive correlation existed between the scores on the pre-class responses and the scores on the final exam in Introduction to Geotechnical Engineering and Mechanics of Materials. These findings suggest that incorporating web-based pre-class reading responses can be an effective way to improve student engagement and performance, particularly in complex, concept-heavy courses. Instructors might consider adopting similar strategies to boost preparation and participation, thereby enhancing learning outcomes across engineering subjects.

Due to the small sample size, it is challenging to make conclusive recommendations based on the observations. The results of this study, limited to the data from 2022-2023, should not be generalized to broader conclusions. Further data collection and analysis over several more course offerings are necessary to draw informative conclusions. Future studies should encompass different courses with larger sample sizes. Engineering faculty can create a more engaging and effective learning environment in their courses by incorporating the strategy used in this study.

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