Investigating Students' Long-Term Retention of Mohr's Circle Concepts

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Abstract

Mohr's Circle is a critical concept for determining failure conditions in the field of geotechnical engineering. Most students struggle to successfully retain and transfer Mohr's Circle concepts from a Mechanics of Materials course to an introductory geotechnical engineering course. A pre-test of Mohr's Circle key concepts was developed and administered in an introductory geotechnical engineering course at The Citadel. The pre-test was employed to assess students' long-term retention of Mohr's Circle concepts at the beginning of the course. This Work-In-Progress study examines the pre-test data from sections of Introduction to Geotechnical Engineering taught in fall 2019 and fall 2020 at The Citadel.

Keywords

Mohr's Circle, Retention of Knowledge

Background

Mohr's Circle is a graphical illustration of the two-dimensional state of stress at a point [1,2]. Generally, Civil Engineering majors are first introduced to Mohr's Circle concepts in a Mechanics of Materials course. The importance of understanding Mohr's Circle in soil mechanics is paramount to learning more advanced topics in future geotechnical classes. At the Citadel, Civil Engineering majors are required to take Mechanics of Materials and Introduction to Geotechnical Engineering in the first semester of junior year and first semester of senior year, respectively.

Two of the most important educational goals are promoting retention and transfer of learning[3]. Retention is the ability to remember material at some later time in much the same way it was presented during instruction as explained by Mayer[3]. Transfer is the ability to use what was learned to solve new problems, answer new questions, or facilitate learning new subject matter[4]. In short, retention requires that students remember what they have learned, whereas transfer requires students not only to remember, but also to make sense of and be able to use what they have learned[5-6]. As stated in the literature, robust learning has the following qualities: (1) when students learn material, they should still be able to recall and use the material after a period. (2) they should be able to use the material in different situations. (3) the material students learn should enable them to learn related material later[7]. Bransford and Schwartz[8] assert that effective transfer requires a sufficient degree of original learning. Literature[6] also states that many approaches to curriculum design make it difficult for students to organize knowledge meaningfully. Often there is only superficial coverage of facts before moving on to the next topic, which means there is little time to develop any form of retention of knowledge.

Study Methods

The following describes the guiding research question for this study: To what extent are Civil Engineering majors able to retain and transfer Mohr's Circle concepts that they have learned in Mechanics of Materials course to an introductory geotechnical engineering course?

To investigate research question, a three-question pre-test was developed based upon the key Mohr's circle concepts (see Table 1) that geotechnical engineering instructor believes that students entering his course should know. The pre-tests were administered to measure students' long-term retention of Mohr's Circle concepts and to identify student misconceptions at the beginning of the semester.

Table 1. The short-answer questions on the pre-test.

Q1. The center and radius of a Mohr Circle have been computed to be C = 800 psf and R = 500 psf, respectively. What is the smallest normal stress that will be developed on any plane?
Q2. For a given state of stress, what level of shear stress acts on the principal planes?
Q3. The major and minor principal stresses at a certain point in the ground are 450 and 200 kPa, respectively. Determine the maximum shear stress at this point.

Results and Discussion

Figure 1 illustrates the mean and standard error score (in percentage) for each question and analyzes students' performance on each question on the pre-test. The pre-test means for Questions 1-3 range from 48.6% to 53.4%, 11.6% to 13.5%, and 16.3% to 24.3%, respectively. Student performance at below 50% level on all three questions is an extremely poor performance, indicating little to no retention of these concepts. These low scores suggest that students do not adequately retain Mohr circle concepts between their initial exposure in Mechanics of Materials and the start of their introductory geotechnical engineering course. The strongest score on the pre-test was Question 1 (What is the smallest normal stress that will be developed on any plane?). The weakest scores on the pre-test were Question 2 (what level of shear stress acts on the principal planes?) and Question 3 (The major and minor principal stresses at a certain point in the ground are 450 and 200 kPa, respectively. determine the maximum shear stress at this point). Study resulted in a large variation in the pretest standard deviations. The pre-test standard deviation for Questions 1, 2, and 3 range from 47% to 51%, 32% to 35%, 37% to 44%, respectively. This study reveals that the Mohr's Circle concepts gained in Mechanics of Material course is lost within one year. Perhaps, the Mohr's Circle concepts were not learned at deep level.

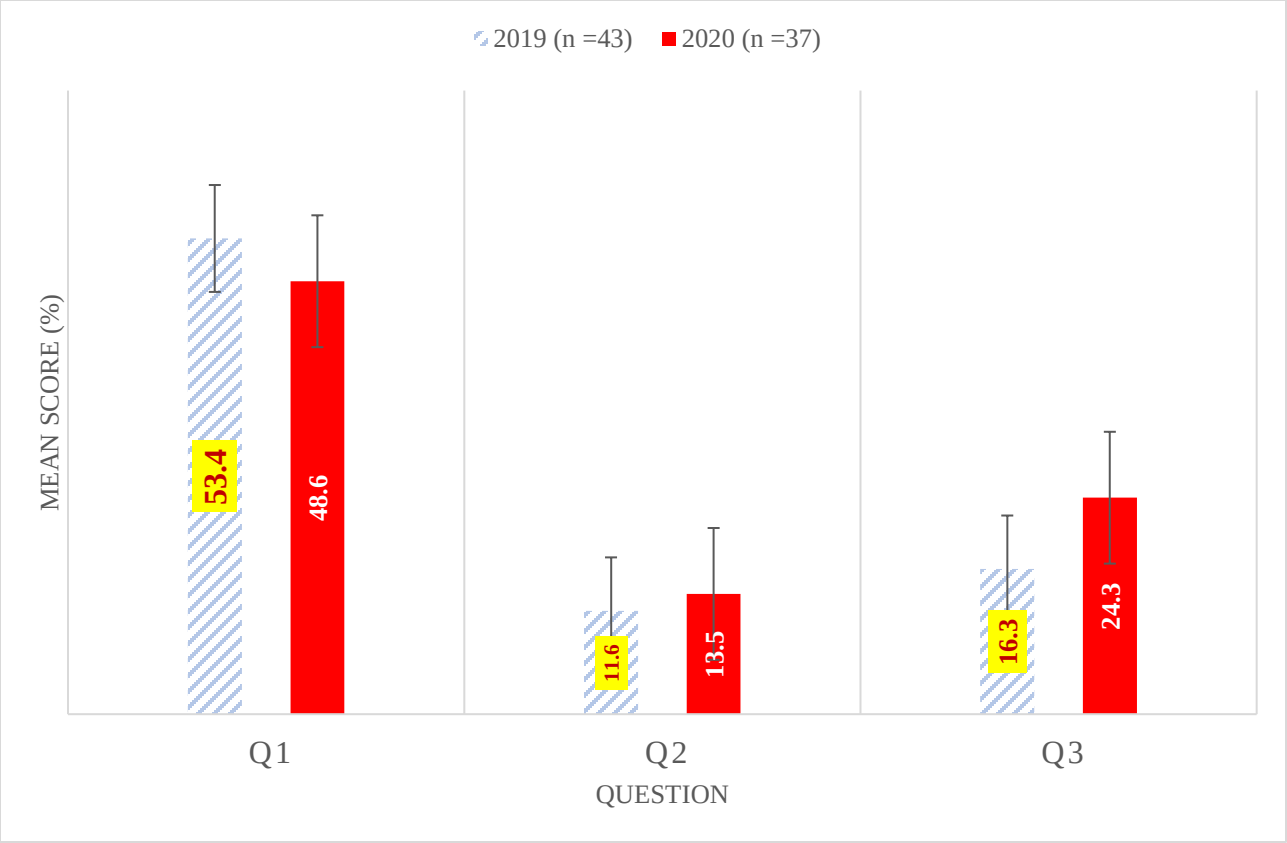

Figure 1. Means and standard errors in percentage for each question on the pre-test

Conclusions

This study assessed the extent to which students retained and transferred the relevant Mohr's Circle concepts from a Mechanics of Material course to an introductory geotechnical engineering course at The Citadel. The following conclusions can be made based on the study results:

- Students' pre-test scores on Mohr's Circle questions were lower than expected, even though a course in Mechanics of Materials is a prerequisite for Introduction to Geotechnical Engineering. Students were not capable of demonstrating basic understanding of key Mohr's Circle concepts.
- Low scores suggest that students do not adequately retain Mohr's Circle concepts between their initial exposure in Mechanics of Materials and the start of their introductory geotechnical engineering course. Perhaps, retention and transfer of Mohr's Circle knowledge has not occurred due to an insufficient degree of original learning. Retaining Mohr's Circle concepts requires students to fully understand the material and believe that they matter.
- It is difficult to move beyond observations into recommendations due to the small sample size. Further data collection and analysis is warranted over the next few offerings.

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