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Assessing the Influence of Lecture/Laboratory Instructor Pairings on Student Perception and Learning Outcomes

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Introduction

Courses in a large majority of science and engineering curricula are often complemented by laboratories which provide a learning environment different from a traditional lecture. These laboratories promote student engagement through problem-based learning, resulting in increased student performance, increased student confidence in the subject material [1], and greater enjoyment of the subject material by the students [2]. The lecture courses which these laboratories supplement are often substantially different in size, with one lecture linked to multiple smaller laboratory sections. The connection between these lectures and laboratories has long been observed to play a vital role in the effectiveness of many science and engineering courses [3], [4].

Student performance in the paired lecture and laboratory courses can be affected by several variables. Taking the lecture and laboratory in separate semesters has been shown to negatively affect student performance and retention [5], [6]. The lectures and laboratories are commonly taught by different instructors, which can cause variations in content integration, topic emphasis, nomenclature, and teaching style. Literature on integrated lecture/laboratory models has noted improvement in student performance in many science and engineering courses ranging from introductory physics and biology to digital signal processing [6]-[9]. Careful coordination of strategies between lecture and laboratory instructors has been shown to raise student performance as well [10].

It is common practice among many colleges and universities in the United States to regularly assign laboratory instructors that are not concurrently teaching the associated lecture course. This can range from graduate students at research-focused institutions to tenure-track faculty at teaching-focused institutions. Regardless of the level of qualification of the laboratory instructors, this disconnect between the lecture and laboratory course instructor can create a host of challenges for student learning. The argument can be made that students need to be capable of overcoming any differences in terminology, notation, content delivery, as well as in teaching and learning styles. A point can also be made that consistency is key to student learning when it comes to foundational engineering courses, such as Mechanics of Materials lecture/laboratory course.

Although unique in its own right, The Citadel is no different than other teaching colleges and universities when it comes to the assignment of lecture and laboratory course instructors. However, regardless of the institution, faculty assignment to a paired lecture and laboratory course, especially in lower-level undergraduate courses, is usually dependent upon instructor availability due to upper-level course demands during a semester. Additionally, instructor course load, past performance, and available funds may dictate the use of an adjunct or instructor (non-tenure track) versus tenure-track faculty in a lecture/laboratory course. Therefore, lecture/laboratory instructor pairings are usually low priority because of the aforementioned reasons for course assignment. The purpose of this study is to examine the impact of lecture/laboratory instructor pairings on learning outcomes and student perception.

Study Methods

Course Description

At The Citadel, Civil and Mechanical Engineering majors are required to take Mechanics of Materials lecture (CIVL 304) and laboratory course (CIVL 307) in the first semester of junior year and second semester of sophomore year, respectively. CIVL 304 is a three-credit course that meets for 2.5 hours of lecture (twice a week for 75 minutes each) and CIVL 307 is a one-credit course that meets once per week for 2 hours. The main topics of the course include stress, strain, deformation, and stress/strain transformation. In the three-semester duration of this study, three faculty members (Instructors A-C) taught lecture sections and one faculty member (Instructor C) taught laboratory sections (Table 1). Instructor C taught one section of CIVL 304 and two sections of CIVL 307 in fall 2017. The syllabi, textbook, and topics covered were identical for all lecture and laboratory sections. For this study, the summer cohorts and fall cohort are treated as equivalent. It should be noted that Instructor A is an early-career tenure-track assistant professor with less than five years of teaching experience, Instructor B is a full professor with approximately 15 years of teaching experience, and Instructor C is a seasoned tenure-track assistant professor with at least 20 years of teaching experience in multiple settings.

Table 1. Lecture and laboratory instructors

Semesters	Lecture (CIVL 304) Instructors	Laboratory (CIVL 307) Instructors
Summer 2016	Instructor A (N =24)	Instructor C (N =24, 2 sections)
Summer 2017	Instructors A (N=20) and B (N=15)	Instructor C (N =29, 2 sections)
Fall 2017	Instructors A (N =22) and C (N=20)	Instructor C (N =26, 2 sections)

An indirect assessment was performed in fall 2017 to capture student perceptions on the challenges and benefits of lecture and laboratory course instructor pairings. Direct assessment data were collected over span of three semesters and consist of student performance on a quiz on material properties from information presented in both the lecture and the laboratory courses.

Survey of Student Perception of Having Same Instructor for Lecture and Laboratory

The survey of student perception of having the same instructor for lecture and laboratory was conducted in CIVL 304 sections on the first day of the fall 2017. Students were asked to respond to eight statements listed in Table 2. Table 2 is a reproduction of the survey. The student perception was measured by analyzing a ‘1-5’ Likert scale survey (‘1’ indicating that students strongly disagree with the statement and a ‘5’ indicating that students strongly agree with the statement). The mean and standard deviation of each survey response was determined and the results are shown in Table 3.

Table 2. Survey of student perception of having same instructor for lecture and laboratory

Q1. Having same instructor for both lecture and laboratory helps to better connect the theoretical and practical aspects of subject matter. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q2. Having same instructor for both lecture and laboratory helps to develop better rapport with the instructor. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q3. With two different instructors for lecture and laboratory, I have a chance to develop better rapport with at least one of my instructors. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q4. Having same instructor for both lecture and laboratory helps to have a better grasp of the concepts. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q5. Having same instructor for both lecture and laboratory helps with reinforcing lecture topics. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q6.Having same instructor for both lecture and laboratory helps to reduce opportunities for gaps in information or contradictions in explanations about concepts. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q7. Having same instructor for both lecture and laboratory helps with a better understanding of what was presented in class. Strongly Disagree 1 2 3 4 5 Strongly Agree
Q8. Having same instructor for both lecture and laboratory helps understand the concept better since the same terminologies are used in both lecture and laboratory. Strongly Disagree 1 2 3 4 5 Strongly Agree

Table 3. Mean and standard deviation for each survey question

Question	Mean (N =42)	Standard Deviation (N=42)
Q1	4.09	0.82
Q2	4.31	0.68
Q3	3.14	0.9
Q4	3.95	1.01
Q5	4.26	0.83
Q6	4.14	0.84
Q7	4.14	0.93
Q8	4.12	0.83

Evaluation of Survey Results

As shown in Figure 1, only 33% of students agreed or strongly agreed with the statement that with two different instructors for lecture and laboratory, they have a chance to develop better rapport with at least one of the instructors (Q3). On the other hand, 89% of the students perceived having the same instructor for both lecture and laboratory helps to develop better rapport with the instructor (Q4). Figure 1 also illustrates that at least eighty percent of the students either strongly agree or agree with Q2, Q5, Q7, and Q8.

Using a difference of means t-test, results showed that all questions except Q3 were significantly above the neutral value of 3 at a five percent level of significance ($\alpha = 0.05$), indicating that students were generally agreed or strongly agreed.

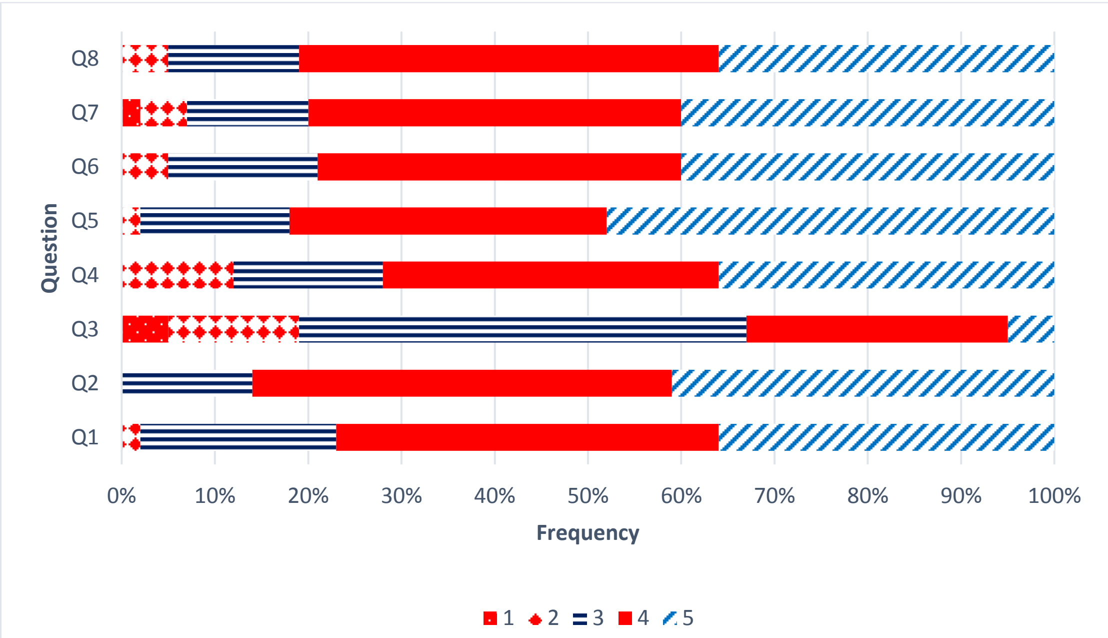

Figure 1. Results of student perception survey

Direct Assessment of Learning Outcomes

Direct assessment data were collected over span of three semesters and consist of student performance on a quiz on material properties from information presented in both the lecture and the laboratory courses. The material properties quiz (see Table 4 and Figure 2) was administered in CIVL 307 each semester. This quiz is significant in that terminology and presentation of material can vary greatly from instructor-to-instructor.

Table 4. The material properties quiz

Q1	Which material is the most ductile in Figure below?
Q2	Which material is the most brittle in Figure below?
Q3	Which material has the largest modulus of elasticity in Figure below?
Q4	Estimate the yield stress for 1060 CR Steel in Figure below using an acceptable approach.

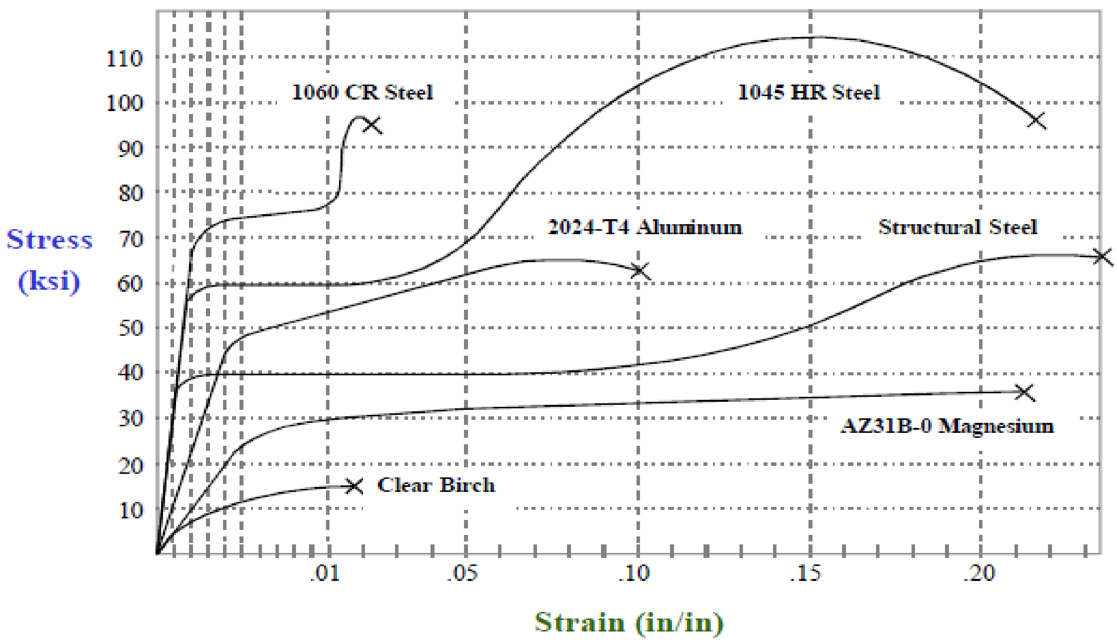

Figure 2. Stress-strain plots of several materials utilized for the direct assessment

Figure 3 illustrates the average student scores from direct assessment quiz. Figure 3 breaks down the average student scores from the direct assessment quiz by semester and section. It is illustrated that there are consistent results in the students' performance for each of the semesters in which there was a different lecture and laboratory instructor pairing while there is a significant increase (~ 10 %) in the performance of the students that were associated with the section that had the same instructor for the lecture and laboratory course. Note that the overall average score

(72.2%) is much closer to the average scores of the students with different lecture and laboratory instructors (i.e., 70.2%, 70.8%, and 69.1%) rather than the average scores of students with the same lecture and laboratory instructor (82.5%) due to the small sample size (N =13).

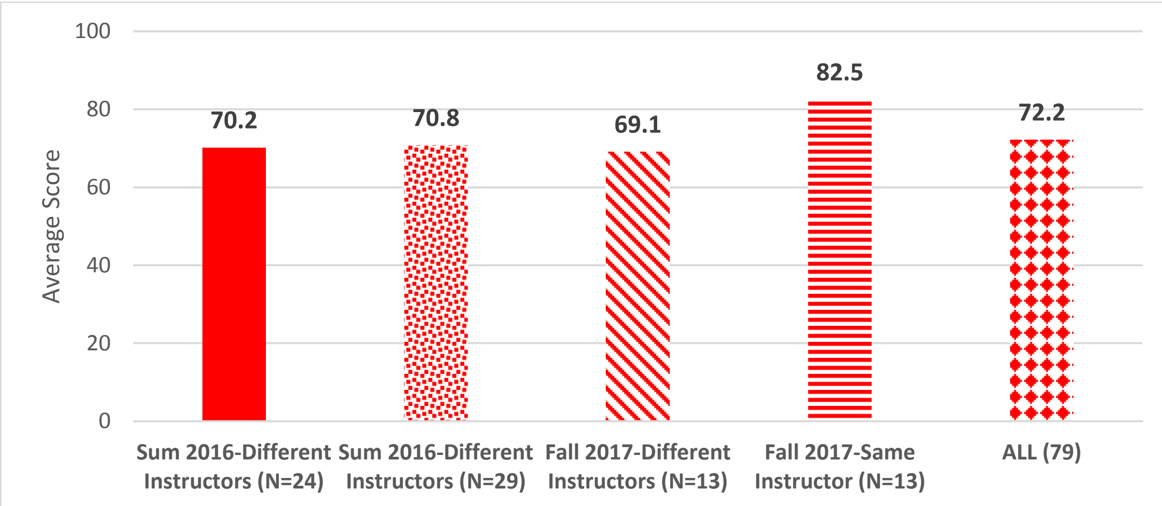

Figure 3. Average student scores per semester and section from the direct assessment quiz

A two-sample t-test statistical analysis was conducted to see if there is a significant difference between the results of the sections that had a different lecture/laboratory instructor (Mean = 70.23) and those that had the same pairing (Mean = 82.5). Comparison of the mean scores was completed using the t-test assuming two-sample with equal variances at a five percent level of significance (α =0.05) and the results are shown in Table 5. The difference between the means was statistically significant (p-value = 0.026) at α =0.05. The results showed that there was a significant difference between the results of sections with different lecture/laboratory instructors and those with the same lecture/laboratory instructor.

Table 5. Results of t-Test: Two-Sample Assuming Equal Variances

	Same Instructor	Different Instructors
Mean	82.4923	70.2321
Variance	352.5641	356.0606
Observations	13	66
Pooled Variance	355.5156	
Hypothesized Mean Difference	0	
df	77	
t Stat	2.2713	
P(T<=t) one-tail	0.01296	
t Critical one-tail	1.6649	
P(T<=t) two-tail	0.0259	
t Critical two-tail	1.9913	

Figure 4 further analyzes students' performance on each question on the quiz. Students with the same lecture and laboratory instructor outperformed others on every question and overall. The results clearly indicate that student performance was increased at least 10% on all four questions of the direct assessment quiz in the section in which students had the same instructor for the lecture and laboratory. Possible reasons for this increase in student performance in the course section that had the same lecture/laboratory instructor could be due to:

- Various pedagogical techniques used by the instructor during lecture and laboratory. To improve the learning environment in Mechanics of Materials and the laboratory courses, a wide variety of teaching and learning tools were employed by Instructor C. The lecture and laboratory learning activities were directly linked to the Mechanics of Materials learning objectives. Web-based pre-class and pre-laboratory reading responses [11] were employed to motivate students to prepare for lecture and laboratory regularly and to inform in-class activities targeting their learning gap. Students were required to respond to one or two open-ended questions on the course website addressing the learning objectives of a specific lesson or experiment. One-Minute paper [12] was used to monitor student learning, which required students to answer a big picture question from the material that was presented in the lecture or laboratory in 60 seconds. The presented lecture material were always related to the material in the laboratory course. The students' misconceptions were corrected and the concepts were conveyed by conducting in-class demonstrations. Laboratory experiments were used to complement concepts learned during lectures. "Real world" laboratory assignment was developed and related to the lecture material, which promoted student learning of concepts and the development of critical thinking skills. Think-Pair-Share active learning activity and a number of other teaching and learning techniques were used in both lecture and laboratory.

- Presentation of course lecture topics in an order such that the laboratory experiments immediately reinforce those topics.

- Better student/instructor rapport within the lecture/laboratory courses that have the same instructor.

- Better implementation of confusion in the actual course material as a teaching tool, as opposed to confusion due to the terminology or emphasis differences between instructors. The following is an example of a student comment "a subtlety in words... Basically, we did not have this professor for lecture. The two professors summarize and use key terms and phrases of the subject matter in minor but different ways. I am always torn between figuring for myself and asking a question in the moment of confusion. This moment turns into minutes which exacerbates the problem into missing more material and more confusion with no point to going back for the question."

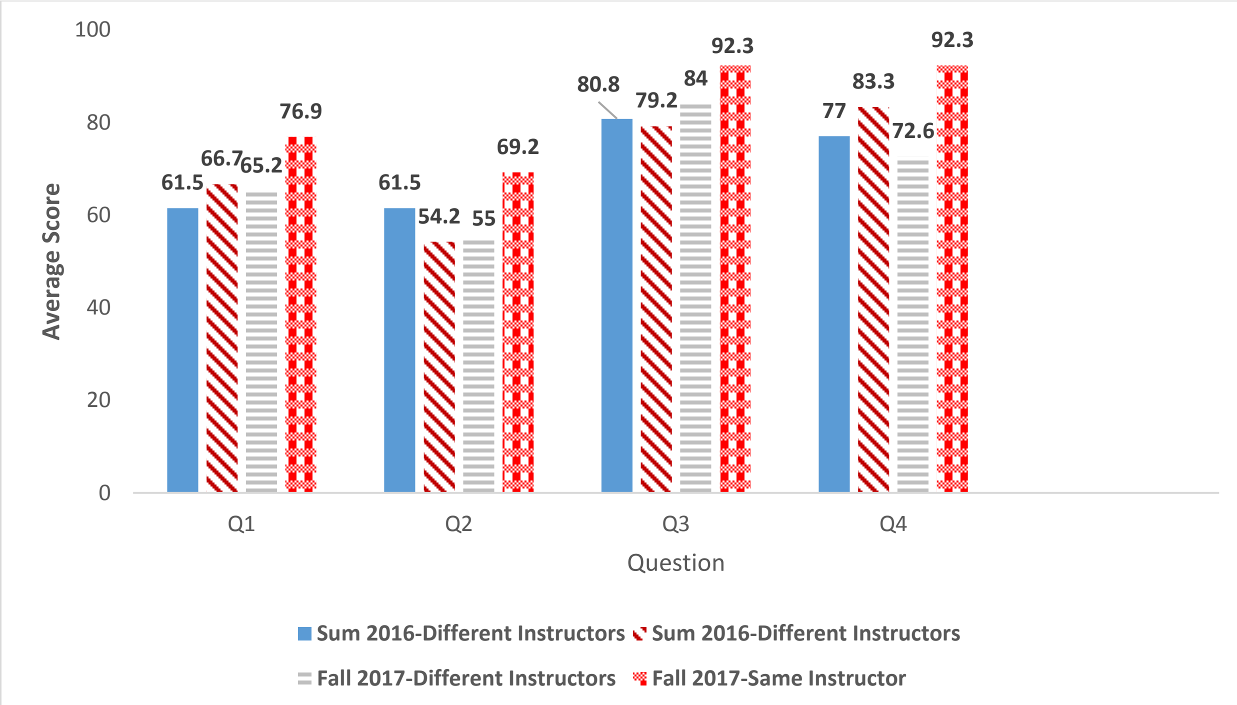

Figure 4. Direct assessment results for each question

Conclusions

A study was conducted to assess the influence of lecture/laboratory instructor pairings on student perception and learning outcomes. The results of direct and indirect assessments show that both learning outcomes and student perceptions are significantly influenced by lecture/laboratory instructor pairings. However, it is difficult to move beyond observations into recommendations due to the small sample size (one section – number of students N=13) for the scenario in which students had the same lecture and laboratory instructor pairing.

It is important to note that the results of this study are limited to the three semesters (with N = 79 student samples) assessed and should not be generalized to draw broader conclusions. Further data collection and analysis is warranted over the next few offerings before conclusions can be made, especially since the improvement of about 10% is modest. Future work with the expanded dataset will explore potential reasons beyond the lecture-laboratory pairings, such as instructor experience, pedagogy and student grade point averages, in an effort to determine if the increase in student performance can be attributed to having the same instructor for both the lecture and the laboratory. In addition, the future perception survey will be administered at the beginning and at the end of semester to determine how the student's perception changes from pre- to post-survey.

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