Student Assessments of Learning Objectives as a Study Tool

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Abstract - Learning objectives are a clear way to provide brief and explicit statements of expected student performance for a given subject matter. Their development is driven by the overall course objectives and they are utilized as a framework for evaluating student understanding and progress. This paper describes the adoption of new learning objectives within an upper-division, senior-level introductory geotechnical engineering course. As part of the study, the objectives themselves were evaluated by the students enrolled in the course to verify their overall efficacy as a study tool for the materials covered in the course. The students were allowed to comment on the learning objectives and provide feedback on their relative usefulness in preparing for course assessments such as exams.

Keywords: Learning Objectives, Study Tools, Geotechnical

INTRODUCTION

Learning objectives provide brief statements about what students should be able to do to demonstrate mastery of the subject matter upon completion of the learning process. [1] Research has recognized their use as an effective teaching method to address the needs of the modern engineering classroom and has shown that students learn more effectively when they are informed of the learning outcomes and evaluation standards prior to assessment. [2, 3, 4] In addition to benefits for students, learning objectives enable instructors to effectively design course assessment materials such as homework assignments, examinations, and projects. Moreover, an organizational structure based on learning objectives provides a model for development of efficient daily lesson outlines and logical sequencing of course material. [5] In essence, the learning objectives define the end goals by which course activities are structured, which allows for a "backward design" process that fosters student learning. [6]

Proper formulation of learning objectives is a non-trivial exercise, as evidenced by the growing literature on their development. [e.g. see 1] Effective learning objectives are unambiguous and are formulated in a way that describes measureable outcomes. Bloom's taxonomy, as summarized in Table 1, often forms a basis by which measureable action verbs are developed for learning objectives. [7] This assures outcomes are mapped to the appropriate level of student cognitive development and promotes proper sequencing of learning objectives for complex subject matter.

The purpose of this paper is to document the effectiveness of learning objectives as a study tool for students within an upper-division, senior-level introductory geotechnical engineering course at The Citadel (CIVL 409: Introduction to Geotechnical Engineering). The learning objectives were developed prior to the beginning of the course and they comprehensively summarized all the material that would be covered throughout the semester. These objectives provided a continued point of reference as the course progressed and they formed the basis for examination development. A total of 56 objectives were formulated, with a larger concentration in the latter half of the course where the subject matter becomes increasingly complex and maps to higher levels on Bloom's taxonomy. This material necessitates a sequential series of learning objectives that piece together a single concept. The increased concentration is thus necessary to ensure the objectives remain clear, concise, and measureable for complicated subject matter. The objectives for each topic were summarized on a set of introductory PowerPoint® slides and were referenced for the students as they were completed in lecture. Examples of the learning objectives can be found in Table 2. These learning objectives reflected a new pedagogical approach for the course and it was the goal to assess the usefulness of the objectives in the context of student learning and adoption as a study tool. To accomplish this, the learning objectives developed for the course were evaluated based on assessment by the students themselves.

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Table 1. Bloom's Taxonomy

Achievement Level	Characterization
Knowledge	consists of facts, conventions, definitions, jargon, technical terms, classification, categories, and criteria.
Comprehension	the ability to understand and grasp the meaning of material, but not necessarily to solve problems or relate it to other material.
Application	the use of abstract ideas in particular concrete situations
Analysis	consists of breaking down complex problems into parts
Synthesis	involves taking pieces and putting them together to make a new whole.
Evaluation	a judgment about a solution, process, design, report, material and so forth using expertise/experience in the area.

DESCRIPTION OF RESEARCH STUDY

It was the goal of this study to explore the effectiveness of the learning objectives as a study tool for students. To accomplish this task, the learning objectives were assessed directly by the students in a series of surveys administered throughout the semester-long course. The survey research instrument was self-developed and is provided in Table 3. It consists of a series of 10 statements about the course learning objectives, to which the students respond using a Likert-type scale to assess level of agreement or disagreement. [8] To diminish the effects of acquiescence bias, an equal number of positively and negatively keyed responses were utilized. In addition to the 10 statements, additional information was requested from the students in the form of comments to guide continued refinement of the learning objectives.

The survey was administered at the beginning of class on two separate occasions during the course. The first occasion occurred at roughly 7 weeks into the semester and the second occurred at roughly 15 weeks into the semester. These timeframes corresponded to classes immediately following an examination, which ensured the examination material and the students' particular study habits were fresh in their memories. The students were informed about the research study and the confidentiality of their responses.

Participants in the research study consisted of students enrolled in any of the three sections of CIVL 409 for which the author was the instructor. This resulted in a collection of 52 possible student participants. Very little variation existed in the instruction method for all three sections. All sections were exposed to the learning objectives in the same manner and were assessed using identical examinations, homework assignments, and design projects throughout the semester.

RESULTS OF STUDENT ASSESSMENT OF LEARNING OBJECTIVES

The first administered survey resulted in 45 completed responses out of the 52 total students enrolled in the three sections. The anonymity of the study meant that it was impossible to note which students completed the questionnaire. As a result, only the students who participated in the first survey were asked to complete the second survey when it was passed out on the second occasion in class. Despite this request, the second survey resulted in 50 completed responses. Three of the surveys completed on the second occasion contained answers of only an obvious single polarity (i.e. only "5 – Strongly Agree") despite an equal number of positively and negatively keyed statements. These responses were disregarded to reduce any misrepresentation of the opinions of those who attentively completed the survey. Thus only 47 responses were analyzed for the second survey, which still represented a net increase of 2 additional respondents compared to the first survey. To normalize the data for comparison, the keyed responses to the statements were reported as percentage of students relative to survey sample size rather than number of students.

Table 2. Examples of Learning Objectives Developed for CIVL 409 Course

Topic	Learning Objective
Soil Geology	1. Explain the difference between soil and rock for geotechnical purposes. 2. List and describe different soil formation methods.
Soil Composition	1. Define "phase diagram" and explain its usage in determining properties of soils. 2. Define the following soil properties: Void Ratio, Porosity, Saturation, Water Content, Density, Unit Weight, & Specific Gravity. 3. Use a phase diagram to solve for volumetric/mass properties of a given soil. 4. Analyze the effects of changing volume or mass on soil properties.
Stresses in Soils	1. Define "Effective Vertical Stress" based on Total Vertical Stress and Pore Water Pressure. 2. Calculate the total vertical stress, pore water pressure, and effective vertical stress profile for a given soil layer geometry. 3. Predict the effects of soil profile changes on the total vertical stress, pore water pressure, and effective vertical stress at a point within the soil profile. 4. Describe the necessary circumstances for a soil to develop "Quick/Boiling Conditions". 5. List the assumptions of the Boussinesq solutions for increases in vertical stresses. 6. Use the Boussinesq solutions to calculate the changes in vertical stress within a soil mass due to loading.
Consolidation	1. Define "Consolidation" and identify the soil type most affected. 2. List the three components of settlement in soils and indicate how much each component contributes to the overall total settlement of a sand and of a clay. 3. Identify events that typically cause consolidation of a clay. 4. Define the following soil consolidation properties: C_C, C_R, σ_p', and OCR. 5. Use laboratory consolidation results to determine C_C, C_R, σ_p', and OCR. 6. Describe the effects of sample disturbance on consolidation soil properties such as C_C and σ_p'. 7. Calculate 1-D consolidation settlements for a soil. 8. List the assumptions of Terzaghi's Consolidation Theory for time rate of consolidation. 9. Predict the time necessary for a given consolidation settlement to take place based on Terzaghi's Consolidation Theory. 10. Predict the spatial distribution of pore pressures in a soil at a given time based on Terzaghi's Consolidation Theory. 11. Compute the coefficient of consolidation (c_v) based on given laboratory consolidation testing results. 12. List four methods that are utilized to mitigate excessive consolidation settlements.

Table 3. Student Survey

	1 – Strongly Disagree	2 – Disagree	3 – Neutral	4 – Agree	5 – Strongly Agree
1.	The learning objectives have consistently prepared me for the material presented in lectures.				1 2 3 4 5
2.	The learning objectives have not accurately described the level of performance that was expected from me in this course.				1 2 3 4 5
3.	The learning objectives are not clear and concise.				1 2 3 4 5
4.	The learning objectives have consistently prepared me for the homework assignments in this course.				1 2 3 4 5
5.	The learning objectives have consistently prepared me for the examinations in this course.				1 2 3 4 5
6.	I would prefer all of my courses to describe the learning objectives.				1 2 3 4 5
7.	The learning objectives are an efficient study tool for the examinations in this course.				1 2 3 4 5
8.	The learning objectives have not contributed to my learning experience in this course.				1 2 3 4 5
9.	The learning objectives have not allowed me to better understand the material presented in this course.				1 2 3 4 5
10.	The learning objectives have not improved my performance in this class.				1 2 3 4 5
Note any comments about the learning objectives and any changes that could enhance their effectiveness as a study tool:					

Figures 1 – 3 were developed to organize the data in a way that provides meaningful insights about the progression of student attitudes towards learning objectives throughout the course. Each figure contains the tabulated data arranged in bar chart format. Figures 1 and 2 provide the results from each of the surveys independently. The modal score for each of the statement responses is readily apparent from the highest percentage listed on each bar chart. Also included with each chart is the mean value and the standard deviation of the tabulated responses based on assigning them numerical values (i.e. 1 – 5). Figure 3 presents the responses from the first survey alongside the responses to the second survey to compare similarities and differences between student viewpoints on the learning objectives as the course progressed. The analysis and evaluation of this data is presented collectively due to the linked nature of the surveys and the various learning objectives utilized. A number of interesting and useful quantifiable observations regarding the learning objectives can be noted from the data presented in Figures 1 – 3:

- Generally, the majority of students (86%) agreed that the learning objectives allowed them to be better prepared for lecture. This was true as the semester progressed with only a very slight shift to neutrality towards this statement on the second survey. In both surveys, not a single student disagreed with the notion that learning objectives enhanced course lectures and prepared them for class.

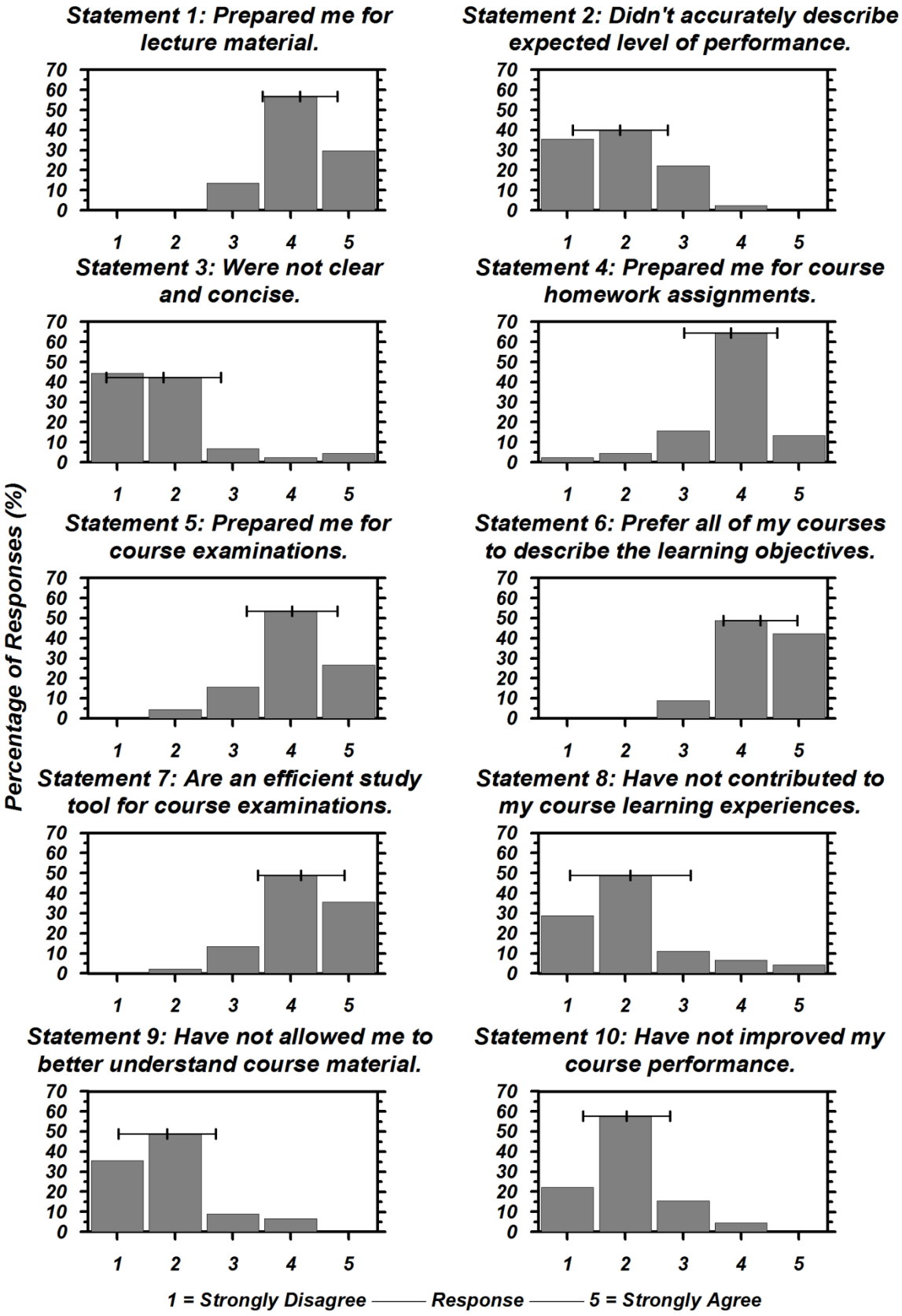

Figure 1. Results of first in-class survey. Error bars illustrate the mean plus or minus one standard deviation.

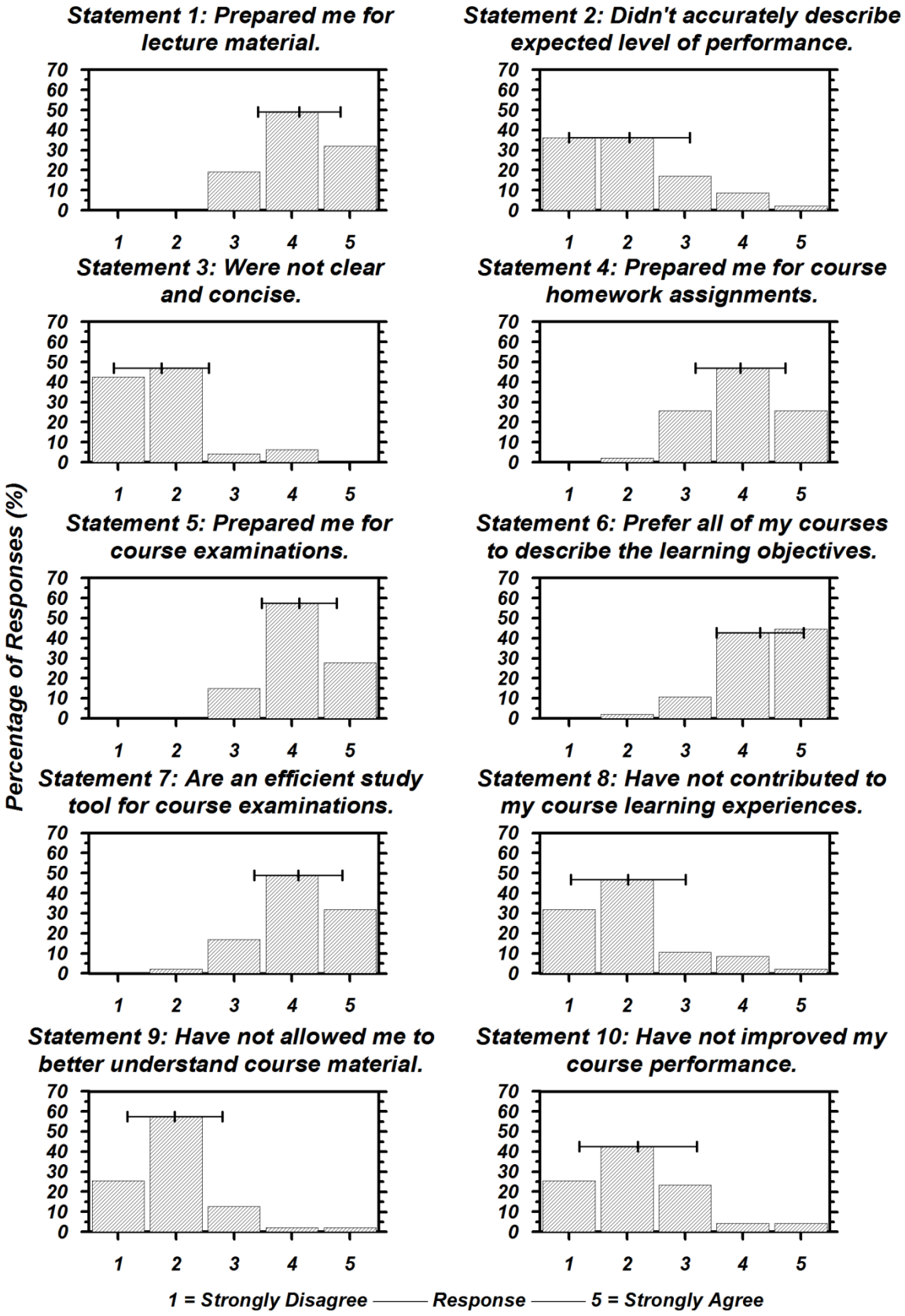

Figure 2. Results of second in-class survey. Error bars illustrate the mean plus or minus one standard deviation.

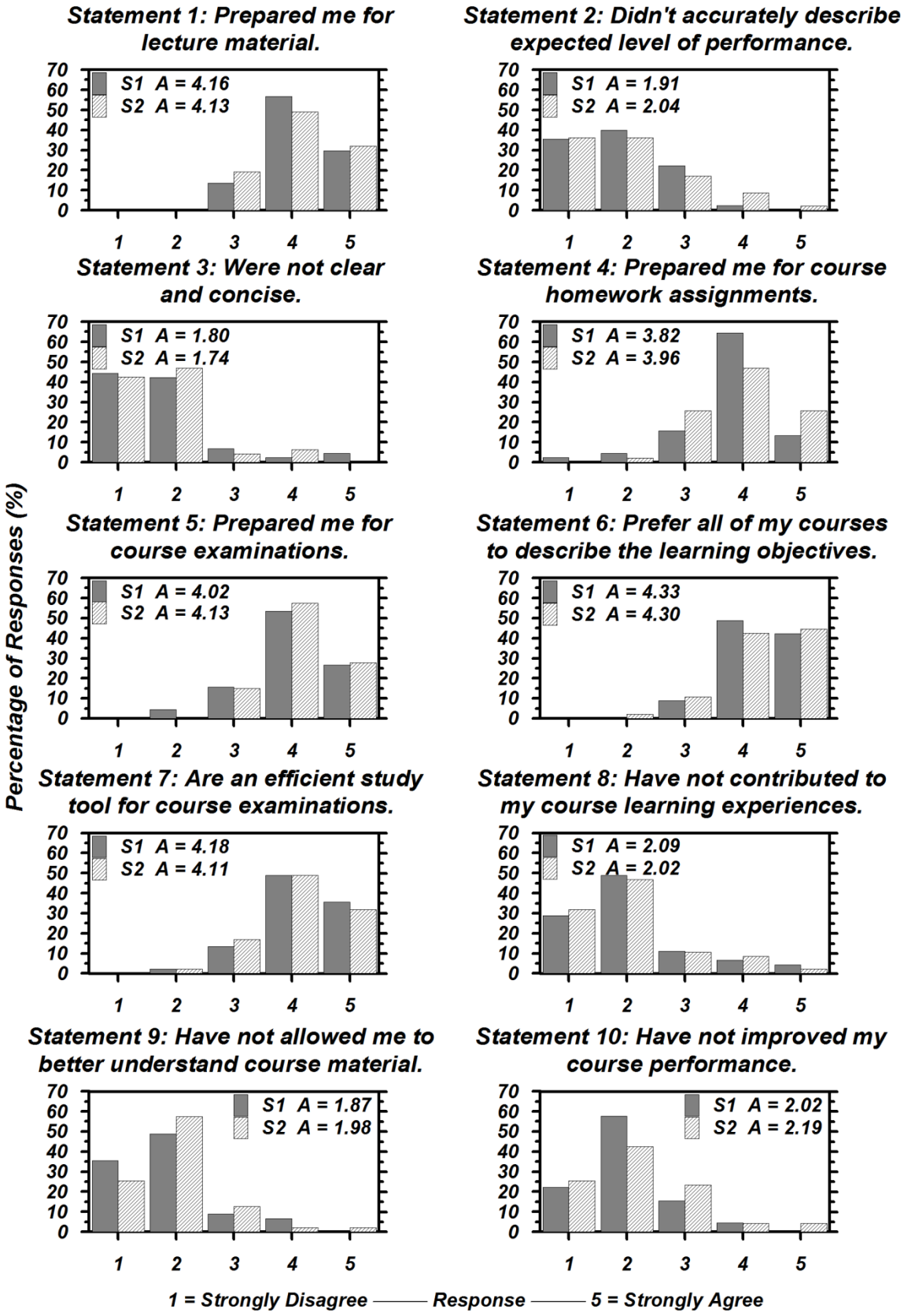

Figure 3. Comparison between the results from the first in-class survey (S1) and the second in-class survey (S2).

- There was a little less consensus on the how well the learning objectives were actually articulated. Statement 2 measured how accurate the objectives were in expressing course expectations and Statement 3 directly addressed whether the learning objectives were well written. A few students expressed dissatisfaction about how well the objectives were delineated based on their responses to these two statements. Additionally, the percentage of those dissatisfied with how well the objectives described expectations increased slightly after the second survey. This highlights the importance of devoting time to write clear and concise learning objective that accurately describe course expectations, which becomes more difficult as the subject matter becomes more complex in nature. Additionally, learning objectives must form the basis for course assessment tools (e.g. examinations) in order for their continued success and adoption by students as a study tool.

- In general there was a tendency towards agreement with the notion that the learning objectives assisted in completion of homework assignments. However, this agreement was modest after the initial survey (mean score $A = 3.82$ and 65% or respondents merely agreed rather than strong agreed). After the second survey, there was a tendency towards slightly stronger agreement (mean score $A = 3.96$ and 25% of respondents strongly agreed) and away from disagreement. This was likely due to the generation of homework assignments that more closely incorporated the learning objectives as the semester progressed.

- The students generally agreed that the learning objectives prepared them for the course examinations slightly more so than the homework assignments. This is exhibited by the smaller percentage of people who disagreed with Statement 5 compared to Statement 4. Additionally, there was small shift towards agreement after the second survey – and therefore the second examination – as noted by the slight increases in positive responses and the complete lack of negative responses.

- The overwhelming majority of students (91%) preferred if all of their courses adopted learning objectives to guide students in understanding the course material. Of these students, nearly half of them strongly agreed that all classes should incorporate learning objectives. This statement generated the highest mean score on both surveys ($A_1 = 4.33$ and $A_2 = 4.30$) and some of the smallest standard deviations ($\sigma_1 = 0.64$ and $\sigma_2 = 0.75$). All response scores were normalized to a scale of 5 for this comparison (i.e. negatively keyed responses were reversed such that strong disagreement resulted in a score of 5). The results for this statement indicate that students highly regarded the learning objectives despite any flaws in their execution.

- The main research question for this study was encapsulated in Statement 7 which directly measured how well students perceived learning objectives to be an efficient study tool for course examinations. The results for this statement generally painted a favorable impression with nearly 85% of respondents agreeing or strong agreeing that learning objectives make a good study tool after the first survey and 81% after the second survey. There was a very slight shift towards a more neutral stance on the second survey, which could be related to the difficulty in writing clear objectives for the difficult material covered in the second examination and strictly adhering to them in the examination development. However, despite these difficulties very few respondents (2% in both surveys) believed that the learning objectives did not function as an efficient study tool. Given the broad range in student study habits and preferences, this level of agreement is impressive. Moreover, a few students commented on the survey regarding the learning objectives as a study tool. Anecdotally, these students identified that the learning objects served as a "blueprint" by which they conducted their review of course notes and textbook chapters. They identified example problems for each of the learning objectives in preparation for the examinations and ensured they could resolve those examples at the level of understanding prescribed in the objectives.

- The final three statements (Statements 8 – 10) relate to the perceptions of the students that the learning objectives contributed to their overall course learning experiences, performance, and understanding of the subject matter. Consequently, these statements broadly measure how well the learning objectives advanced the pursuit and acquisition of knowledge within the context of this particular course. Interestingly, despite very strong agreement that all courses should incorporate learning objectives and that they are very useful as a study

tool, there was slightly more spread in the responses to these series of statements. In particular, Statement 8 nearly garnered the highest standard deviation for both sets of surveys ($\sigma_1 = 1.04$ and $\sigma_2 = 0.99$) and there was a small percentage of respondents who actually did not believe the objectives contributed to their learning experiences. A possible explanation may be that some students just had strong ideas about what their learning experiences consist of and learning objectives did not "fit in" with their assessment of what improved those experiences. In fact, by developing the course to revolve around learning objectives, these students may have actually been distracted with their continual incorporation into lecture. These same students may have still seen the overall value of the objectives for the rest of their classmates, which is why they were unable to disagree with the notion that all courses should utilize learning objectives. In general though, the broad trend was still the majority of participants felt the learning objectives created a better overall learning experience, improved their understanding of the course material, and ultimately led to increased performance. For example, the mean scores on second survey for Statements 8, 9, and 10 were $A = 2.02$, $A = 1.98$, and $A = 2.19$, respectively, which denotes disagreement with the premise of each of the statements.

SUMMARY

This paper documents the perceptions senior-level undergraduate students enrolled in an introductory geotechnical engineering course at The Citadel had about learning objectives, as self-reported on confidential questionnaires. The overall consensus was that these students thought very highly of the learning objectives and felt the objectives were an effective study aid and benefited their experiences in the course. Though not measured directly prior to implementation of the study, anecdotal evidence from conversations with the students suggested they did not anticipate this level of course enhancement due to the use of learning objectives. Notably, the overwhelming majority of students in this study agreed with the notion that all courses should incorporate learning objectives into the curriculum. It is also clear that care must be exercised in generating the objectives and properly matching them to course assessments such as examinations and homework assignments in order to maximize their effectiveness.

CONCLUSIONS

The author feels that other engineering faculty interested in exerting a modest amount of effort to improve student experiences in a course may find benefits by incorporating learning objectives as documented in this paper. As evidenced by the data in the study, some of these benefits could include improved understanding of course subject matter, better preparation for course examinations, and improved performance as self-reported by students enrolled in the course.

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