Adding Student Led Components to FE Review Courses to Improve FE Examination Scores at The Citadel: A Case Study

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Abstract – In 1995, following several years of Fundamentals of Engineering (FE) Examination pass rates around 50 percent, the Civil & Environmental Engineering Department initiated a faculty led FE review course that was organized by the American Society of Civil Engineers (ASCE) Student Chapter at the Citadel. This paper presents the preliminary results of a study being conducted to improve student scores on the general exam by implementing student mentoring and student led instruction in addition to the components of the existing review course program. In particular, a student facilitator encouraged and motivated senior students to participate in a self-graded practice exam prior to the actual exam in order to evaluate weak areas for each student and also examined the motivation of juniors (one year prior to taking the exam) by providing extra credit opportunities for these students in a mechanics of materials course.

Keywords: FE, Fundamentals, Engineering, and Assessment.

INTRODUCTION

In 1995, following several years of Fundamentals of Engineering (FE) Examination pass rates around 50 percent, the Civil & Environmental Engineering Department at The Citadel initiated a faculty led FE review course that was organized by the American Society of Civil Engineers (ASCE) Student Chapter. The course content and structure has not significantly changed over the past 10 years and student pass rates around 70 percent have been typical since the course was installed. Table 1 provides an historical summary of civil engineering student scores at The Citadel since 1993. The student scores are not normalized and the passing rate shown is the raw passing rate for students and the national average passing rate is for the particular exam. Although not shown in Table 1, it was recorded by the ASCE Student Chapter that in the 2000-2001 and 2001-2002 academic years, students attending the review sessions had passing rates of 80 percent and 78 percent, respectively. These rates are significantly higher than the reported values that include all students. It is also clear that on the average, student scores have increased significantly since the rebate for attendance policy was installed (1998) into the review course. This paper presents the preliminary results of a study performed to examine the impact of student led activities on student motivation and performance on the FE Exam. As part of this study, a student facilitator encouraged and motivated senior students to participate in a self-graded practice exam prior to the actual exam in order to evaluate weak areas for each student and also examined the motivation of juniors (one year prior to taking the exam) by providing extra credit opportunities for these students in a mechanics of materials course.

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Table 1. Historical summary of civil engineering FE Exam scores at The Citadel (adapted from [1]).

Academic Year	Description of Review Activities	National Average Passing Rate	CEE Student Pass Rate at The Citadel
1993 - 1994	No formal review	Unavailable	58%
1994 - 1995	No formal review	Unavailable	52%
1995 - 1996	First review course installed: provide students with reference book from NCEES	72%	57%
1996 - 1997	Review course modified to include active learning (less lectures and more problems)	74%	51%
1997 - 1998	Same as 1996 - 1997	71%	55%
1998 - 1999	Charge $40 for the workshop and return $30 if student misses no more than two sessions (over 80% received money back)	63%	74%
1999 - 2000	Same as 1998 - 1999	78%	64%
2000 - 2001	Same as 1998 - 1999	77%	67%
2001 - 2002	Same as 1998 - 1999	77%	62%
2002 - 2003	Same as 1998 - 1999	81%	88%
2003 - 2004	Same as 1998 - 1999	79%	63%
2004 - 2005	Same as above but install student led components into the review course and a complete rebate	Not yet available	Not yet available

General Background

Engineering programs are required by the Accreditation Board for Engineering and Technology (ABET) to document their continuous efforts to improve their programs, as well as the outcomes. Alumni surveys, student portfolio reviews, and capstone projects are some of the methods commonly used for assessment; however, a majority of these measures are subjective in nature [2]. Thus, a considerable obstacle facing universities exists in devising a method to quantitatively evaluate engineering student performance and gauge the effect of a change within a program. It has been suggested in the literature that the results of the Fundamentals of Engineering (FE) examination can be used as an institutional assessment tool and many programs use these results in some fashion or another [3].

Many variables are addressed in assessing the validity of the FE exam as an assessment tool. The FE Exam's major use is as a preliminary qualification to attain licensure, and the exam is typically not mandatory [4]. A 1988 survey found that at only 26 of 199 campuses was there a mandatory FE requirement, and only 16 of these had a college-wide requirement, with 3 requiring that the student pass [5]. Formerly, the exam comprised 15 topics, where a large proportion of the topics were in areas where only one three hour course in an entire curriculum was devoted to them. This prompted the National Council of Examiners for Engineers and Surveyors (NCEES) to revise the scope and format of the FE exam. The test now includes general engineering areas as well as several different discipline-specific areas [6]. These changes allow students from a wide range of programs to be tested objectively, ameliorating the allegation that the test favored certain engineering disciplines too heavily.

Studies have shown that while technical competency is the most important factor to passing the FE exam, level of motivation to pass the test is the next most significant contributor. Mazurek documentated an attempt at a military academy, similar to the one at which this study was conducted, to use the examination to assess engineering

programs at the school [2]. At the school, it was found that cadets consistently had lower pass rates than national averages, and the study showed this to be the result of several factors. The departmental policy required all engineering majors to take the FE exam prior to graduation, but the school's primary mission is to produce military officers, so the cadets were not sufficiently motivated to pass the exam. Further, it was concluded that the exam was not discussed extensively in courses, resulting in many learning of the exam's existence from other cadets.

Another report analyzed the breakdown of the FE exam results from 57 universities through three different bias eliminating measures in an effort to identify best and worst practices within and between institutions [7]. Nirmalakhandan presented a study that addressed subject-specific results on the FE exam, and his conclusion entailed two three-credit hour courses, as well as coordinating departmental instruction to improve scores. Also, some caveats were identified for using the FE exam results for program assessment: test difficulty may vary from year to year and results may be invalid if examinees are preselected or if courses were to "teach for the FE exam" [2,7,8].

This paper presents an approach similar to one utilized by Koehn, which implements the use of practice examinations [9]. Koehn's approach entailed a seven-week review of the engineering sciences, which compose approximately two-thirds of the examination, and practice examinations. The student's motivation dictated whether the remaining one-third of the material was reviewed, and independent student evaluations were conducted. The study found that well-motivated students who completed the review course experienced an extremely high passing rate on the FE exam (100% for civil engineers).

The study described in this paper was conducted at The Citadel, in Charleston, SC. Due to the nature of the institution, about 30% of the cadets directly enter the military, detrimentally affecting the level of motivation to pass for a large portion of the sample [2]. A seven-week review course was conducted, and professors from the institution reviewed topics that were to appear during the morning session of the examination, such as mathematics, dynamics, chemistry, fluid mechanics, and engineering economy. Near the completion of the review course, a student led practice examination was conducted to simulate the examination's environment. The practice test was one half the length of the actual test, and solutions were provided for students to subsequently identify questions answered incorrectly. The students then reworked incorrect answers with the aid of printed solutions to further understand any mistakes made while testing. To examine the motivation of junior students one year prior to taking the FE Exam, a student led effort to assess knowledge in one particular subject area, mechanics of materials, was performed by providing students extra credit for answering twenty multiple choice questions to include all areas of the subject covered the exam.

SUMMARY OF 2004-2005 REVIEW COURSE

The 2004-2005 academic year FE Exam review course organized by the ASCE student chapter included around 40 participants, 23 of which were current civil engineering students. Other attendees consisted of current electrical engineering students and outside professionals that also took the FE Exam in October 2004. As in years past, the student fee for the course was set by the ASCE student chapter at $40. However, this year students were told that they would receive all of their money back ($30 back in prior years per Table 1) if they attended all of the sessions. They were also informed that any exception to this rule would require officer approval. Approximately 80% of the current civil engineering students received their rebate for attending all of the courses.

The student led component added this year to the FE review course included participation in a voluntary practice exam for all civil engineering students taking the exam in October 2004. The practice exams (general morning /civil specific afternoon) were purchased from NCEES and are assumed to be representative of the actual examination. The practice exam was intended to serve two purposes. The first purpose was to prepare the students for the format of the morning exam and the expected level of difficultly of the questions in this section. Since The Citadel's civil engineering students typically elect to take the civil specific afternoon section, it is expected that the morning section questions covering the general material would be more basic in nature. The second purpose of the practice exam was to provide some type of review for the civil specific afternoon section. In its existing format, the FE review course at The Citadel has no formal review of the civil specific section and students are only as prepared as they become on their own. By taking the exam in the fall of their senior year, Citadel civil engineering students have not had key classes covered on the FE exam that include steel design, environmental engineering, foundation

design, etc. At this point, it is important to note that in contrast to many other schools that encourage their students to take the exam during their final (i.e., spring) semester, students at The Citadel are encouraged to take the exam in the fall semester so that they can take the exam twice, if they need to, prior to graduation. Although, by inspection, this approach lowers the passing rate of Citadel seniors during the fall semester, it provides a method to increase the percentage of students passing the exam prior to graduation.

Table 2. Raw scores from practice exam taken by civil engineering seniors one week before October 2004 FE Examination.

Morning Raw Score	Afternoon Raw Score	Morning % Correct	Afternoon % Correct
47	23	78%	77%
40	20	67%	67%
40	18	67%	60%
15	10	25%	33%
30	15	50%	50%
30	14	50%	47%
25	16	42%	53%
27	21	45%	70%
24	14	40%	47%
30	20	50%	67%
40	14	67%	47%
25	15	42%	50%

Fifty-two percent of civil engineering seniors participated in the student led practice exam. Table 2 presents the students' raw scores. Since actual scores on the exam are not yet available, the practice exam scores cannot be compared to the actual scores at this time. However, student feedback from the seniors participating in the practice exam indicates that the practice exam helped alleviate concern over on what to expect on the actual exam and has encouraged the ASCE student chapter to include this new component in the future.

SPECIAL STUDY ON JUNIOR MOTIVATION IN A MECHANICS OF MATERIALS COURSE

The second new student led component added this year included participation in a voluntary practice exam (20 questions) in a mechanics of materials course taught at The Citadel. Students were permitted to take the practice exam during class time and received nominal extra credit (1 point on final exam) for participation. No additional credit was given based on performance. The purpose of this practice exam was twofold. The first purpose was to assess the motivation of junior civil engineering students towards preparing for the FE Exam, which at the time of the practice exam was about one year away. The second purpose was to see how unprepared students taking a particular course (i.e., mechanics of materials) would perform on a practice exam covering FE tested material on this course topic. During the last two scheduled classes of the semester, students were provided with copies of the Fundamentals of Engineering Supplied-Reference Handbook [10] section covering mechanics of materials and briefly (15 minutes) introduced to the content covered in that section. Students were then given the rest of the class and the entire next class to take a 20 question multiple choice practice exam on material in the reference handbook. The questions were adapted from several FE review references and purposely addressed all topics indicated in the Fundamentals of Engineering Supplied-Reference Handbook [10]. Two of the questions covered topics or definitions not specifically addressed in the mechanics of materials course. Figure 1 shows a comparison of student performance on the FE practice exam in various subject areas vs. student performance on in-class assessment quizzes (not specifically related to the FE Exam) as administered by the professor. Course assessment results for pressure vessels was only covered in homework assignments and is therefore not shown in Figure 1. Several subjective conclusions can be reached. Scores on the FE practice exam material are lower than course assessment

results primarily as a result of the relative complexity of the FE practice problems and the students' lack of preparation prior to the assessment. Also, although about half of the students seemed motivated to do well on the practice exam, the lack of significant reward led some students to simply guess and spend the provided class time studying for other classes (instructor was informed of this by the individual students and several students indicated that they had a major exam the following period).

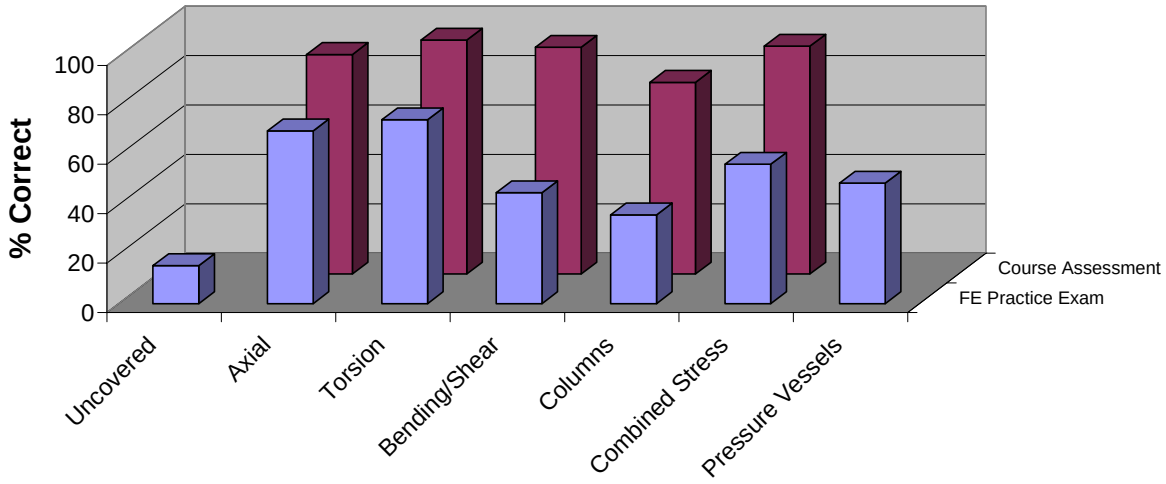

Figure 1. Comparison of FE practice exam results in mechanics of materials course and assessment quizzes on the same topics given by the class instructor.

CONCLUSIONS

In conclusion, it is clear that motivation plays a key role in student performance on the FE Exam and that the ASCE Student Chapter at The Citadel must continue to modify and improve its review course in order to increase passing rates on the examination. Future improvements may include recommending all students take the exam during the spring semester so that all the civil specific material will have been covered in classes and a student led civil specific review course can be offered in the spring semester. Other improvements may include mandatory participation on practice exams in order for students to receive fee rebates. This is a preliminary and ongoing study at The Citadel, and as improvements continue to be made and more data becomes available, test performances should reflect the increase in emphasis. Future research will include thorough statistical analyses of FE exam performances and results.

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