The Use of a Fundamentals of Engineering Course to Enhance the Capstone Experience

David W. Johnstone[1], Charles D. Newhouse[2]

Abstract – In the past, the capstone design course acted as a primary assessment for progress and knowledge. The shortcoming to this approach, however, was that less emphasis was placed on preparing to become a professional engineer, beginning with passing the FE exam. In an attempt to combat this deficiency, a senior-level course covering the fundamentals of engineering was offered in the fall as an additional component to the spring semester capstone design course. The success of this course has been overwhelming yielding a pass rate for first-time test takers of nearly 83%. By offering a course in the fundamentals of engineering, the students gain valuable knowledge of subject matter not extensively covered throughout the curriculum and have the opportunity to clarify additional subject matter. In doing so, the students may then be accurately assessed on both the fundamentals and design of engineering practice.

Keywords: FE Exam, Professional Engineer, Civil Engineering, Curriculum.

INTRODUCTION

The daily life at the Virginia Military Institute (VMI) is unlike most college campuses. Aside from the core curriculum and required courses in their major, cadets are required to take seven physical education classes, eight ROTC classes, and participate in mandatory military training. While these additional activities provide leadership qualities and prepare young men and women for a career both in the military and in the private sector, they do not necessarily facilitate success in specific engineering topics.

The current civil engineering curriculum at VMI contains 34 semester hours of basic math and science combined with 65 semester hours of required engineering courses which include six semester hours of engineering science electives, nine semester hours of technical engineering electives, six semester hours of engineering design, and a three semester hour capstone design course. Of all the engineering courses, the capstone design course is the primary course that utilizes problem-based learning to combine the knowledge and skills acquired throughout the students' tenure at VMI to complete a design project. While this course has been used to assess the students' knowledge of engineering design, it does not effectively prepare a student for the first step in becoming a professional engineer which begins with passing the Fundamentals of Engineering (FE) exam.

Most civil engineering students at VMI have the opportunity to take the FE exam during both the fall and spring semesters of their senior year though some are not able to take the fall exam due to athletic commitments. Until recently, in an attempt to promote and encourage exam participation, the department paid the registration fee for each student but did not require cadets to formally review or study for the exam. This method, however, was proven unsuccessful as students did not feel the need to pass nor did they want to spend the additional time to independently prepare in an already constrained schedule. In the fall of 2010, 31 civil engineering majors attempted the FE exam yielding a pass rate of merely 16%. With little enthusiasm and a dismal exam performance, it was evident that something else needed to be done.

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During the spring of 2011, the professors at VMI attempted to change the attitudes of the students by reemphasizing the importance of the exam and how it could impact future careers. In addition, review classes were offered in the evenings for those who wished to participate. Attendance was not mandatory yet the turnout was substantial. Results of the spring exam reflected the newfound enthusiasm with pass rates climbing to roughly 61% for the academic year [2]. This improvement, while still below department standards, alluded that the changes taking place were working but needed to be further developed.

In the fall of 2011, a course was developed to cover material encountered on both the morning and afternoon sections of the FE exam. Although the course was originally conceived as a review or preparation course, it became apparent during the development of the course that it could supplement the senior capstone experience. Just as the capstone course would reiterate the design techniques acquired throughout a students' career, the FE course would recap the fundamentals that were learned. With heightened enthusiasm and an opportunity to better prepare for the exam, the course gained instant popularity with 15 of 20 expected graduates electing to enroll in the FE course the first semester it was offered.

2011-2012 FE RESULTS

Due to NCAA and military commitments, only 12 of the 15 cadets enrolled in the class took the FE exam in the fall. Of those 12, 10 passed the fall exam producing VMI's best pass rate on record of roughly 83%. Comparatively, VMI equaled or outperformed the national average pass rate of 77%. Performance in all but five morning subjects and in all but one subject in the afternoon (figure 1) also exceeded the national average.

Eight cadets took the spring exam, five of which had enrolled in the fall FE course and another who participated without official enrollment. Of these eight, four successfully passed the spring exam yet only two of those who passed participated in the fall course. While the pass rate for the spring exam was down for VMI students, similar trends were shown in the national average. The national average dropped from 77% in the fall to 70% in the spring with the national average percent correct in ten subject areas decreasing by more than 10%, five of which exceeded 23%. This showed great variability in the performance of students nationwide between the fall and spring exams. Nonetheless, the overall pass rate for the VMI graduating class of 2012 was nearly 79%, the second highest pass rate in the past seven years and a significant improvement from the VMI civil engineering average (figure 2).

In order to assess the success of the course, the pass rates for first time test takers were compared. While it is apparent that a few students were attempting the test for the first time in the spring, the nature of the test and the means for gathering past test results did not allow these students to be isolated. Therefore, only the fall exam was investigated. Figure 3 shows the fall exam results for the past seven years, six of which were prior to the FE course offering. The average pass rate for this time was nearly 42% with the highest rate in any year occurring in 2006 at 58%. Following the FE course, the fall pass rate for 2011 was a staggering 85% (Note: One student passed the exam without taking the class). It is evident that the FE review course was successful in increasing pass rates at VMI; however, some have asked how this course fits into the curriculum.

JUSTIFICATION FOR THE COURSE

The FE class is currently offered during the fall semester and can be counted as one of the three required technical electives in the civil and environmental engineering (CEE) department. Some have argued that since new material is not being taught in the course, the course should not count for credit. However, there are several counter arguments to this claim.

The first counter argument can be found in the capstone course itself. Nearly every engineering department requires a capstone course that encompasses design from all aspects of engineering taught within the department. While this course typically requires students to perform a design from cradle to grave, additional techniques are not taught but rather applied. The FE course acts in a similar fashion. Subject matter based on the fundamentals is used to further the understanding of all aspects of engineering. It is no surprise that while students take and pass a typical engineering course, they may not fully grasp the concept of what is being taught. By reiterating fundamentals and expressing methods which may vary from original teachings, the students benefit by obtaining a more complete understanding of the material.

A second counter argument is that not all subjects on the FE exam are thoroughly covered within the curriculum. In theory, a student who takes the exam should have obtained knowledge in every category for which

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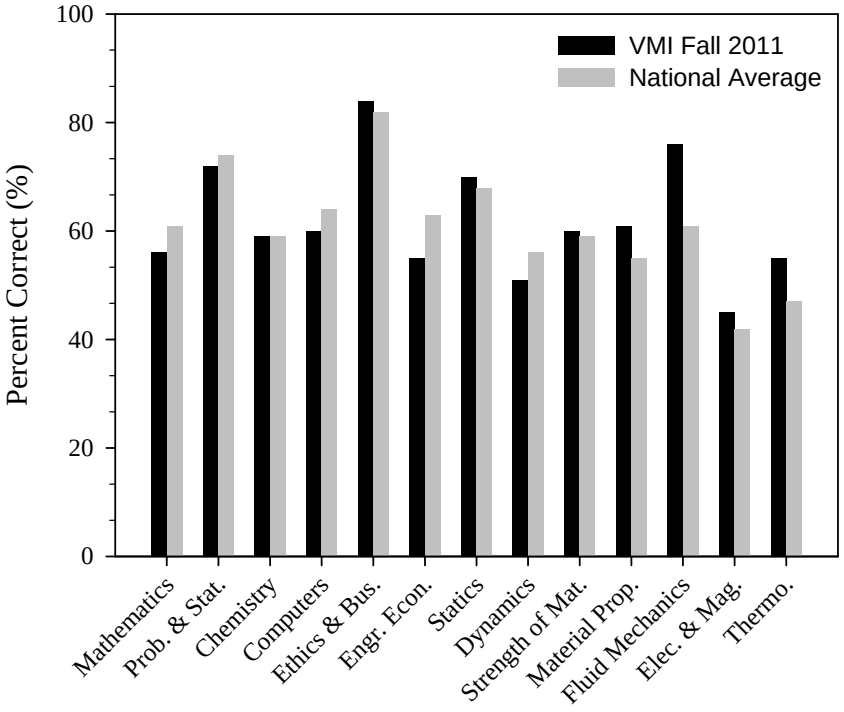

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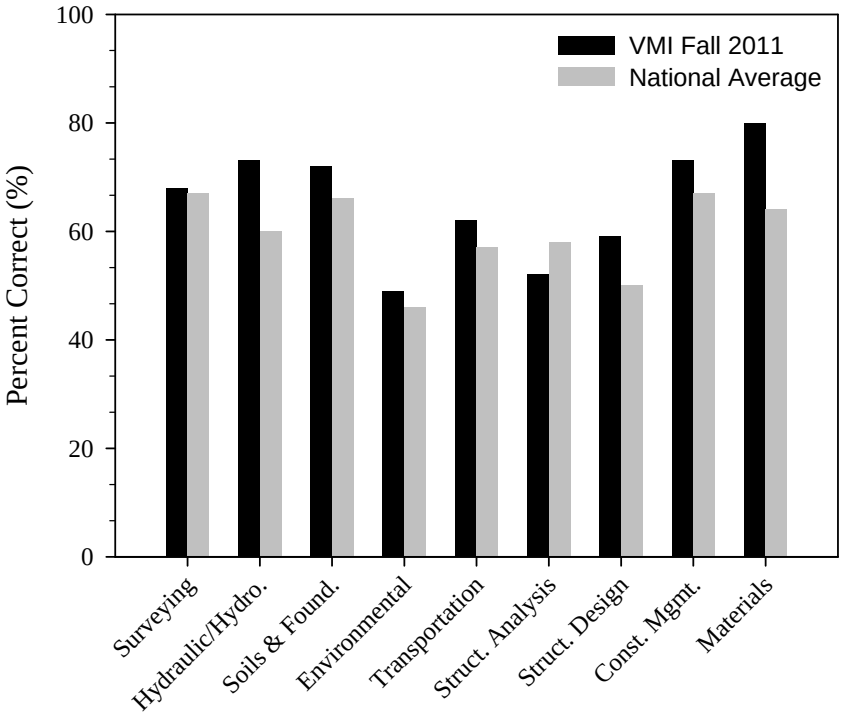

Figure 1. – Comparison of 2011 fall FE results between VMI and the national average for: a) the morning session and; b) the afternoon session.

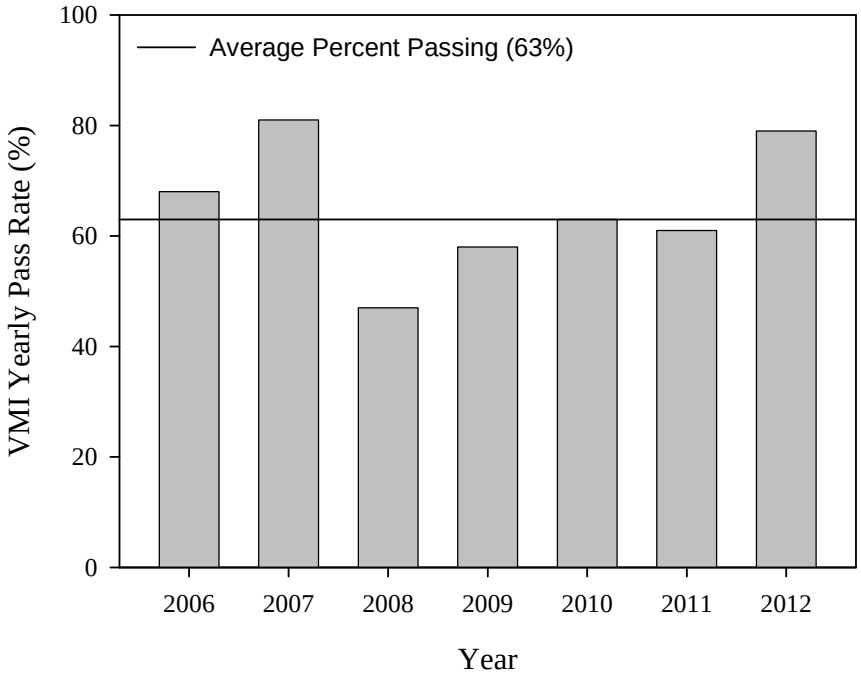

Figure 2. – VMI academic year pass rates for the FE exam over the past 7-years with an average pass rate of 63%.

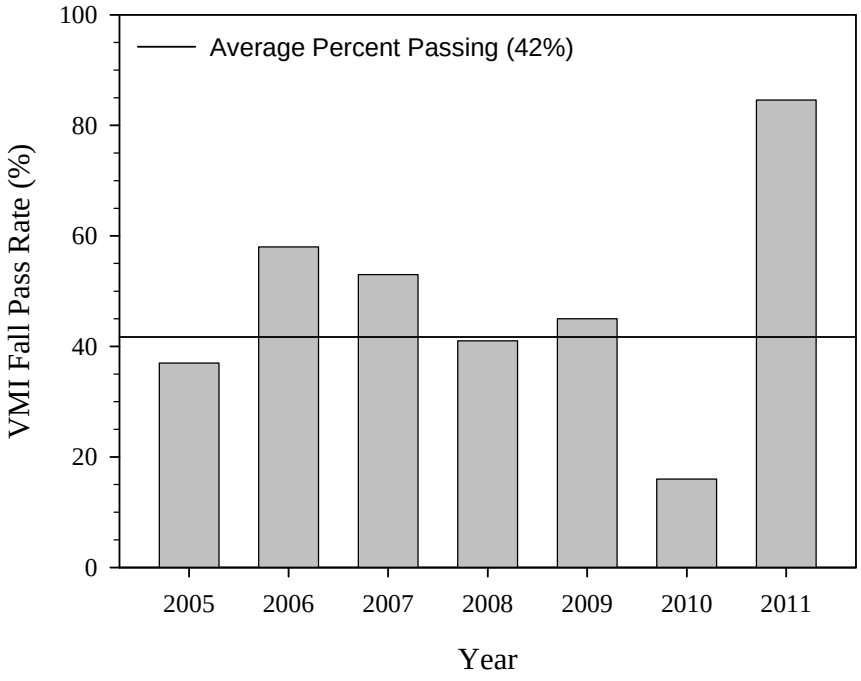

Figure 3. – Fall VMI pass rates for the FE exam over the past 7-years.
* Average pass rate shown prior to fall 2011 exam.

they are tested. Due to variety of engineering and science electives, however, students may not be fully exposed to all areas in engineering. For example, many universities have certain courses which are grouped together as a selected elective (i.e. choose one course from the group). Such is the case at VMI, dynamics, thermodynamics, and circuits are categorized as an engineering science elective group. These courses which may have once been required or are required elsewhere are now eliminated from the required CEE curriculum. While it may be true that some aspects of these courses are taught as a subtopic elsewhere within the institute, as in the case of electrical concepts in physics, they are not covered in engineering detail, are not necessarily applied to engineering type problems, and therefore benefit from additional coverage during the FE exam preparation.

Though it may be difficult for the students to realize the importance of professional registration during their cadetship, the CEE faculty has realized how important it is that they pass the FE exam while at VMI. The VMI CEE department had hoped to improve the mindset of the students by offering this course and allowing it to be accepted as credit within the curriculum. Evidence suggests that this approach is working. Of the 40 expected spring 2013 CEE graduates, 39 elected to take the course in the fall of 2012. This was an even higher class participation rate than experienced during the first offering.

COURSE OVERVIEW

The course has five objectives which are linked to individual ABET Student Outcomes [3]. First, cadets are expected to learn and apply fundamental principles from courses not specifically required in the CEE curriculum. Second, cadets are expected to use principles learned in non-engineering courses to solve engineering problems. Third, cadets are expected to improve competency in specific civil engineering topics. Fourth, cadets are expected to review and relearn topics that they simply may have been forgotten during their cadetship. And fifth, cadets are expected to be able to describe the engineering registration process and requirements to becoming a professional engineer.

Although the course developed into more than just a test preparation class, it still made sense to have the class take place immediately prior to the date of the fall exam. In order to meet the required 42 semester teaching hours within a nine week period ending before the October exam, the course was offered during a typical Tuesday-Thursday time period with an additional Monday afternoon lab session. Therefore, the course took place on an accelerated schedule. Care was taken to make sure that sufficient, but not too much, homework was assigned during the accelerated period. The instructor made sure that the amount of homework assigned did not cause the cadets to neglect other courses. Course evaluations given at the end of the class have indicated that the cadets felt that the amount of work was slightly more than a normal class but reasonable.

During the first class, each cadet was issued (1) the FE Supplied Reference Manual, (2) a copy of a morning section FE preparation book, (3) an FE approved calculator, and (4) a polling response clicker. Cadets were required to use an FE approved calculator and the FE Supplied Reference Manual on all assignments during the entire course.

The first half of the course was dedicated to the material covered during the morning section of the exam. To cover such broad topics, an overview of each topic was covered and specific problems were worked. Homework problems were assigned from the FE Review Manual© [1] and graded primarily for neatness and completion. Cadets were encouraged to first attempt to solve each problem with the aid of the FE Supplied Reference Manual only. Only after they found that they could not solve the problem were they encouraged to look at the provided solution. Some cadets did this well, while others gave up too early and looked at the solution. A clicker quiz using a response polling system was offered every class during the morning section. These quizzes focused on engineering vocabulary and the basic concepts needed for each morning topic. The polling software, which runs inside of Microsoft PowerPoint™, automatically records the correct answer. The clicker quizzes were used for 1/3 of the grade for the course. The remaining grade was composed of 1/3 homework and 1/3 exams. A two-hour morning exam was offered at the mid-point of the course and a two-hour afternoon exam was offered at the end of the course. Each of these two exams was given as timed multiple choice exams to mimic the time allowed on the actual FE exam.

CADET PERCEPTIONS

Cadet perceptions of their experience throughout the course have been generally positive. For the fall 2012 semester, both official and unofficial evaluations were given at the end of the course, prior to learning how they

performed on the FE exam. Most cadets indicated that they would not have studied as much if they had not taken the course. Many felt the immediate feedback from the clicker quizzes, which would show the correct answer after the "clicked" response was submitted, helped to learn the basic concepts, language, and terminology. The clicker quizzes also allowed solutions to be shown immediately after the problem was worked, eliminating the time delay usually experienced after turning in homework or tests. In addition to the clicker quiz problems and problems worked in class and on the tests, approximately 140 homework problems were assigned and graded just for the morning section. Fewer homework problems were assigned for the afternoon section. Most cadets that kept up with the homework realized by the end of the course how much they learned, relearned, and/or finally understood by doing the homework problems.

A few cadets complained about the grading scale for the course. Grades were recorded on a spreadsheet and made available to cadets throughout the semester. The final percent for each category was determined by taking the raw percentage and dividing by a factor to reach an adjusted percent. The cadets were told at the beginning of the semester what the factors would be (0.93 for Homework, 0.80 for Clicker Quizzes, and 0.67 for Exams). The instructor reserved the right to adjust the factors down (which would increase grades). Even though the grading scheme was transparent, some felt that their grades should be higher. It was decided that cadets who pass the FE would have their letter grade increased one grade. This was only available to cadets who took the exam in the fall. For fairness, an extra credit assignment was made available to cadets who could not take the FE exam in the fall due to NCAA or military commitments.

In spite of the normal amount of grumbling concerning the grade structure, the cadets were pleased with the new course offering. One of the most positive aspects of the course appeared to be implementing the use of the FE Supplied Reference Manual. While homework and test problems provided an additional knowledge base, being comfortable with the manual allowed the students more time to focus on the exam questions rather than search for the necessary equations. Even when faced with problems for which they were unfamiliar, the cadets felt that they were able to easily locate the subject in the manual and still make a valid attempt at solving the problem. The department, realizing the value of the manual, has begun to use it for reference in other courses.

CONCLUSION

Using the FE course as a supplement to the capstone design course appears to be a success. Although only limited data exits, the pass rates and the student feedback show the need and desire for such a course. The course does not specifically teach to the exam but covers an array of subject material. This approach has allowed the students to expand their knowledge in some areas and to get a more complete understanding of engineering topics in other areas. The attitude towards pursing professional registration has certainly improved since the implementation of the course. A benefit to the department has been that performance on the FE exam has been reexamined as an additional assessment tool which has provided insight on topics covered within the curriculum. The course has taken its place as a compliment to the capstone experience.

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After working nine years as a consulting structural engineer for MMM Design Group in Norfolk, Va., Charles D. "Chuck" Newhouse returned to Virginia Tech to receive his Ph.D. in Civil Engineering. He spent three years teaching at Texas Tech University before coming to the Virginia Military Institute in 2008 where he is now an associate professor in the CEE Department. He serves as the ASCE faculty advisor and assists with both the yearly Steel Bridge and Concrete Canoe competitions. He is a graduate of the ASCE ExCEEd (Excellence in Civil Engineering Education) Workshop and has served as both an assistant mentor and a mentor.

Only RUB 220.84/month. Capstone: Fundamentals. STUDY. Flashcards.Â Which of the following should be used to irrigate the tube in order to maintain fluid and electrolyte balance? a) tap water b) sterile water c) 0.9% sodium chloride d) 0.45% sodium chloride. C.Â A nurse is reinforcing teaching regarding the use of a cane to a client who has left-leg weakness. Which of the following should the nurse include in the teaching? a) use the cane on the weak side of the body b) advance the cane and the atrong leg simultaneously c) maintain two points of support on the floor d) advance the cane 30 to 45 cm (12-18 in) with each step. C. Which of the following should indicate to a nurse the need to suction a client's tracheostomy? a) irritability b) hypotension c) flushing d) bradycardia. A. A Capstone course is not simply an advanced course in a particular sub-area, nor is it an unstructured project course. A Capstone is designed to be a culmination of your learning, and a chance to develop and express many skills at once: For example, technical expertise and communication ability. Capstone Goals.Â Computer Engineering majors are required to complete a capstone course as part of their graduation requirements. Computer Science majors are encouraged to take a Capstone, although it is not required for CS.Â Description: Students will work on group project that use of Information and Communication Technologies (ICTs) to address global needs with an emphasis on developing countries. Capstone courses are the culmination of the Texas A&M engineering experience, as seniors apply their four years of classroom knowledge to solve realistic engineering problems. The courses prepare manufacturing and mechanical engineering students to use advanced technology to analyze and design engineering elements and systems according to industry standards. Seniors also make significant professional contacts through design projects with industry participants, frequent guest lecturers, and design contests.Â The capstone experience successfully prepares future engineers by bridging the gap between classroom and industry. The Capstone course grade reflects input from both the studentâ€™s classroom instructor (40% of final grade) and the studentâ€™s mentor (60% of final grade). Grading for the class is based on the quality of the students written drafts and final projects, their practice and final presentations, attendance and participation in the Honors Capstone Course, and regular attendance at meetings with mentors.Â During the Honors Capstone semester, the student must document results of the Capstone experience as is appropriate for the specific project type. Within the first month of the Capstone course, the student must submit their final Capstone Project title and choose an objective second reader for the Capstone Project, who may or may not represent another discipline. Fundamentals of Engineering (FE) exam prep courses can help you pass the first time. We review the best courses based on learning styles, passing rates, and more.Â The Balance Careers uses cookies to provide you with a great user experience. By using The Balance Careers, you accept our. use of cookies. x. Project Management Certifications. The 6 Best Fundamentals of Engineering Exam Prep Courses of 2020. Pass your FE exam the first time. â€¢â€¢â€¢ Maskot / Getty Images.Â Capstone Learningâ€™s Fundamentals of Engineering Exam Preparation costs $699 for a one-time purchase. Students can also enroll for a free sample course before purchasing the full package. Best Live Training: Excel Test Prep.