

Improving FE Pass Rates through Changes in Attitude

Charles Newhouse¹, David Johnstone²

Abstract – All engineering students who attend the Virginia Military Institute (VMI) are required to take, but not necessarily pass, the Fundamentals of Engineering (FE) exam prior to graduation. It has been considered acceptable for pass rates to fall slightly below the national average due to the mandatory FE requirement and time constraints which include a rigorous core curriculum, seven physical education classes, eight ROTC classes, mandatory military training, and a “Spartan” lifestyle in barracks. The VMI Civil and Environmental Engineering (CEE) department has recently decided to implement new strategies in an attempt improve the FE pass rate. This paper presents some of the strategies used in the past to prepare students for the FE exam and how changing students’ attitude improves performance on the exam.

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

INTRODUCTION

All students (called cadets) attending the Virginia Military Institute (VMI) have arguably three full-time jobs: academics, military training, and athletics. The academic program guides cadets to a four-year degree in their chosen major in either engineering, science, liberal arts, or social sciences. A rigorous core curriculum of classes is included for all majors. Beginning at matriculation, all cadets are drilled in various aspects of military training and courtesies. This includes a class system where freshmen are called “Rats,” given few privileges, and are not considered part of the corps until they prove themselves worthy. The military training also includes Reserve Officer Training Corps (ROTC) classes taken every semester in addition to the physical military training. All cadets live in barracks and are required to abide by strict rules within a class system that awards privileges as cadets progress towards graduation. VMI has 18 NCAA Division I level athletic teams although it has only approximately 1500 cadets in attendance.[7] All cadets also have to take a physical education class every semester (except the first semester) and pass a fitness test for part of the grade.

There are several common threads that tie the three areas together. VMI places an emphasis on time management which requires cadets to use every available minute productively to complete their academic work. The cadets also administer a single sanction honor code. Any cadet found guilty of cheating is dismissed – there are no alternate penalties. The honor code requires all cadets to sign a “Help Received” statement on all assignments turned in for grade. VMI also strives to develop each cadet into a citizen-soldier, described as “... a person of character who anticipates, responds, and leads in a complex changing world.”[7] Part of developing the citizen soldier is encouraging cadets to seek a commission into either the active service or the reserves upon graduation. Over fifty percent of cadets currently take a commission at graduation. Leadership is also emphasized, with each cadet required to take a three-credit leadership class in addition to their ROTC classes.

All three of the engineering departments require cadets to take, but not necessarily pass, the Fundamentals of Engineering exam prior to graduation. Preparing a student for this eight-hour comprehensive exam is difficult at any college. The additional mandatory requirements at VMI make it uniquely difficult to prepare the cadets to perform well on the exam.

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THE CEE DEPARTMENT AND THE FE EXAM

The Civil and Environmental Engineering (CEE) department has been involved in assisting cadets as they prepare to take the FE exam (originally called part A of the professional engineering exam, then later the E.I.T. exam) for over four decades. Much of the assistance that the department has offered has been assisting with voluntary, as opposed to mandatory, review sessions. An article that appeared in the cadet newspaper in 1967 described how cadets in the Civil and Electrical Engineering departments created a committee that would organize the eleven week review.[1] A faculty advisor helped with the reviews, but the review sessions were typically not done for any grade or graduation requirement. Cadets were encouraged to attend, but attendance was not mandatory.

Since that time, many different methods have been used, some more successful than others. Although the methods have changed throughout the years, the CEE department has previously used methods that reinforce the positive aspects of passing the exam but which required cadets to prepare primarily on their own. The department has typically avoided methods that require cadets to work problems for grade. Part of the reason for this is that VMI has historically wanted cadets to take and pass the exam before graduation, but has not wanted to make passing the exam a graduation requirement. Another reason is that some of the cadets who commission unfortunately do not see the importance in passing the exam. Since they do not see the importance of passing, they do not see the importance of preparing for the exam.

For many years, the CEE department gave a weekly FE assignment as part of the one-credit Senior Seminar class. This became problematic with some cadets who would simply refuse to do the assignments. It was then difficult to tell a cadet that he or she would not graduate because of a one-credit seminar class.

Another method that was recently employed was to require all instructors to incorporate FE style questions into all CEE classes. The difficulty with using FE style questions on exams is that it is inherently difficult to assign partial credit to a multiple-choice question.

At some point, the three engineering departments used endowed funds to reimburse cadets the exam fee when they passed the exam. It was difficult to reimburse cadets who passed in the spring because their scores were not known until after graduation. The policy evolved to where the engineering departments did all of the paperwork and paid for all cadets to take the exam. In the past few years, some have argued that since the cadets do not have to register and pay for the exam on their own, they have no incentive to study. The argument has been made that cadets should "...assume greater responsibility..." in the professional registration process. Therefore, a new policy will soon go into effect requiring cadets to both register and pay their application fees on their own. If they pass, then they will be fully reimbursed; however, deciding how seniors will be reimbursed once they leave has yet to be determined. The CEE department is still debating on how to implement this new policy.

Cadets are encouraged to take the FE exam in the fall and then repeat it, if necessary, in the spring. This method has worked well at VMI for two main reasons. First, the fall exam may be the only opportunity for cadets to pass if they participate in spring athletics. The second reason alludes to the aspect of time. When cadets are approaching spring graduation, it is simply difficult for them to find time to study for an exam that does not count for a grade. By taking the exam in the fall, the information obtained may be used to indicate problematic areas for which the cadets need to improve in order to pass the spring exam.

RECENT PERFORMANCE

A strict class structure exists among the cadets at VMI which leads to some unusual class dynamics. A mentor-mentee relationship between the seniors and the freshmen "Rats" creates a tight bond where the two classes get along well. However, most classes do not get along with the classes immediately ahead of them. Because so much emphasis is placed on the class structure the CEE department has typically considered successful pass rates for the FE exam for an entire class, regardless of whether it takes one or two attempts to pass. These academic or cumulative pass rates are determined by simply taking the total number of cadets in a given class who pass divided by the total number of cadets in that class.

Figure 1 shows typical academic or cumulative pass rates for VMI compared to the fall and spring national average pass rates for the past six years. Academic year pass rates for years 2006 and 2007 were at or slightly above national average pass rates for those years, respectively. The CEE department considers performance for those two years successful. However, if one were to look at the individual fall or spring pass rates compared to the national

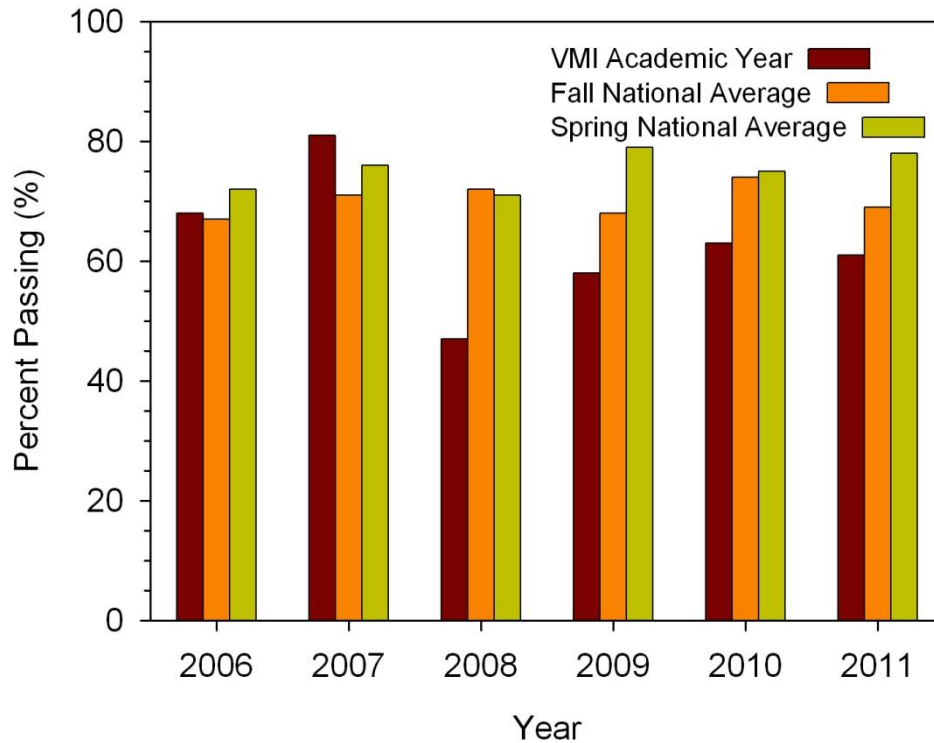


Figure 1 – VMI Academic Year Pass Rates for Past Six Years

average, that person would come to a different conclusion. For example, in 2006, VMI's academic year pass rate was 68% which was between the fall and spring national average pass rates of 67% and 72%. However, VMI's individual fall and spring pass rates of 37% and 50%, respectively, are much lower. The academic pass rate of 68% was determined by taking the number of cadets who passed in October (7 passed out of 19 takers) and adding to the number of cadets who passed in April (6 passed out of 12 takers) and then dividing by the total number of different test takers (19 for this year). VMI considers the academic pass rate more meaningful because the individual fall and spring pass rates do not capture how an academic class as a whole performs compared to the national average.

Figure 1 also shows that the academic year pass rates fell after the academic year ending in 2007 (fall 2006 and spring 2007). It is impossible to determine a particular reason why the rates fell at this time; most likely a variety of factors led to the decrease. Discussions in the CEE department have revealed several possibilities. First, within the CEE department, after a long period of stability within the faculty, there has been a turnover of over 50% of the faculty within the past four years. This turnover has led to revised ways many of the classes have been offered. Second, a revision to the core curriculum took place, causing the department to revise the CEE requirements. To make room for other classes, dynamics was made an elective instead of a required class. Given the opportunity to take dynamics or another course, cadets have overwhelmingly chosen not to take dynamics. Coupled with the fact that electrical theory and thermodynamics are also no longer required, CEE cadets are now at a disadvantage on the morning portion of the FE which has 20% of the questions from these three topics. It should be noted that some of these topics are partly covered in other required classes such as physics. Last, the CEE department requires cadets to gain hands-on experience by offering laboratory classes. Feedback from employers concerning the laboratory classes is positive. However, with the increasing demand on cadets' schedules, it has become difficult to schedule the required classes let alone additional time to prepare for the FE exam.

A less tangible change that has occurred since 2007 has been the change in attitude of the cadets. Recently, the department stopped emphasizing the importance of professional registration as much as it did in years past. The department did continue to do the paperwork for registration and to pay for the exam fees, but it stopped giving review problems during the senior seminar class, placing the burden to study completely on the cadets. In response, many of the cadets failed to prepare much, if any at all, for the exam. They simply failed to see the importance of passing the FE exam.

The National Council of Examiners for Engineering and Surveying (NCEES) institutional summaries provided to VMI after each exam do show the results from the Arts & Sciences plus Professions, No Graduate Coexistence (A&S+Prof/NGC) comparator group. However, these results are not used because they may not accurately represent a true comparison as VMI usually accounts for 100% of the comparator group in the fall and a significant portion, often over a third, in the spring.

ACADEMIC YEAR 2010-2011

In the fall of 2010, performance on the FE exam reached a new low. A class of 31 CEE cadets took the October exam yielding a pass rate of only 16%. Figure 2 shows the average performance for these cadets versus the national average for the various topics. As shown in the figure, cadets performed lower or equivalent to the national average in all subjects. However, the performance did trend or mirror the national average performance. The subjects the cadets were not required to take stand-alone classes for the CE degree or which were not covered extensively in other classes (such as engineering economics) showed the lowest performance.

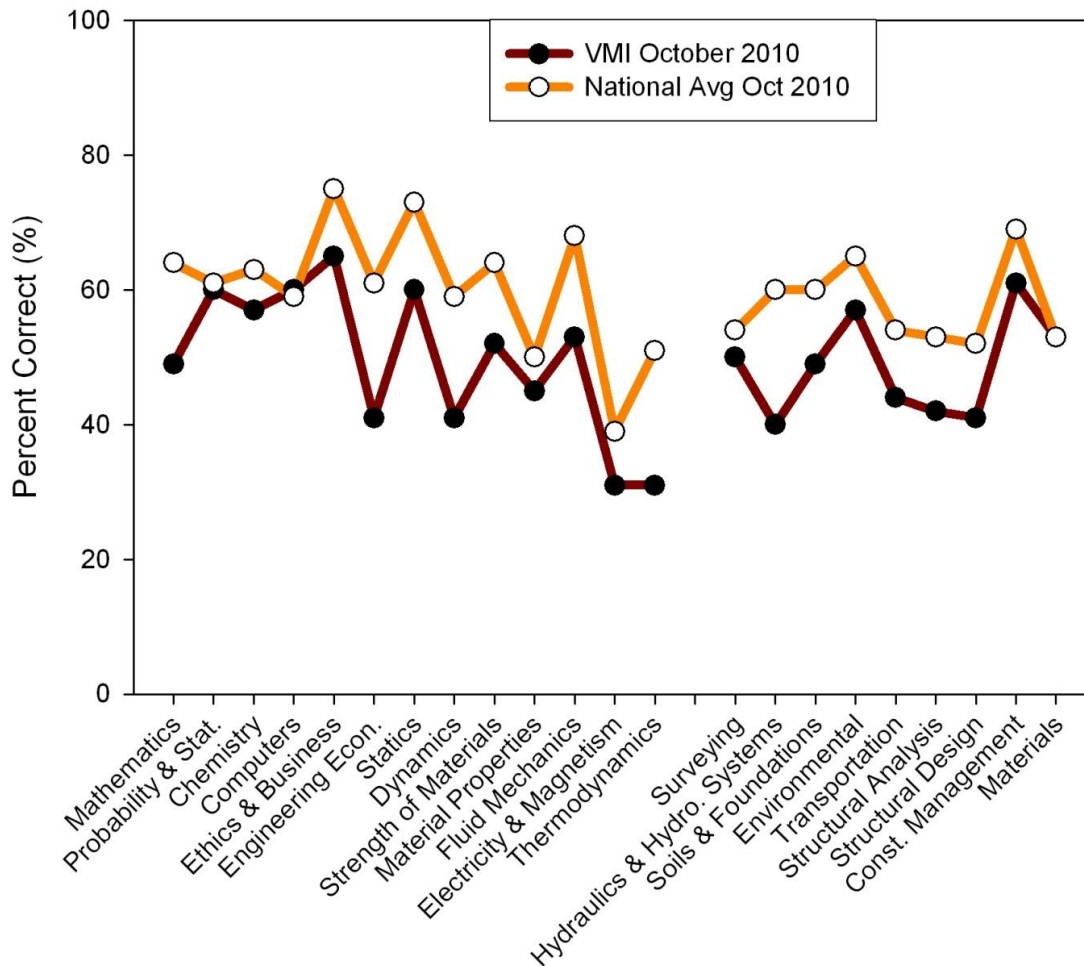


Figure 2 – October 2011 Performance on FE

After the scores were released for the fall 2010 exam, the CEE department decided that something had to be done. The low pass rate was used as a “wake-up” call to begin reemphasizing the importance of preparing for and passing the FE exam. This began by some of the CEE professors talking up the potential importance of passing the FE exam and how doing so could help in the job market. An adjunct professor who had spent a career working as a consultant was able to explain how passing the FE exam could be vital in the current struggling economy. Also, stories from several cadets who commissioned without passing the FE exam, but later decided not to make a career

out of the military, were relayed to the class. Hearing how difficult it can be to pass the exam years after graduation caused many cadets to reconsider the importance of the exam.

Simply placing an emphasis on the importance of passing the exam caused attitudes to improve. Wanting to capitalize on this change in attitude, the CEE department discussed how it could help the cadets improve their performance on the spring exam. Since there were only three months available once the scores were released and spring classes had already started, a formal review could not take place during the day. CEE professors began to offer weekly review sessions at night, covering different topics in each session. The reviews had to take place after dinner (usually at 8:00 p.m.), and consisted of working sample problems from an FE review manual with assigned problems given for the following week. At the beginning of the review, attendance was good, with an estimated 75% of the cadets attending. As the weeks went on, the attendance did drop, but a core of cadets came for many of the sessions. No grades or extra credit were given for attending the review sessions.

Approaching the spring exam, there was a noticeable improvement in the attitude of the cadets. Even those that did not attend all of the review sessions studied as their time allowed and entered the exam better prepared than they were in the fall. The performance did improve in the spring with an additional 14 cadets passing. This produced an academic year pass rate of 61%. This pass rate, although slightly lower than the national average for academic year 2011, was an improvement over the dismal fall performance.

Figure 3 shows the comparison of VMI's October 2010 performance to VMI's April 2011 performance. It is difficult to see the improvement based strictly on percentage of problems answered correctly per subject. Assigning one point to morning problems and two points to afternoon problems indicates that the average score increased slightly from 117 points to 120 points. Improvement was noted in nine subject areas while performance decreased in ten subject areas and remained constant in three subject areas. However, VMI's pass rate increased from 16% to 54%, an increase of 238%. Over the same period the national average pass rate increased from 69% to 78%, an increase of only 13%.

It is possible that the improvement was partly due to the fact that the gap between VMI's performance and the national average was reduced in many subject areas. The areas where performance did not change or decreased slightly did not have as big of a gap in the October exam. Significant improvement occurred in engineering economy, hydraulics and hydrologic systems, soil mechanics and foundations, and structural design. It should also be noted that the April 2011 scores did not include those who passed in October. Removing these good students from the data set should have caused the scores to decrease. However, the average score and the performance in half of the categories each increased slightly.

Before the spring scores were released, the CEE department gave an exit survey to each cadet following the spring exam asking how well they were prepared for each subject. The survey asked cadets to rate "How well were you prepared for each of the following?" subject areas. The cadets were given the choices of: A(Excellent), B(Above Average), C(Average), D(Below Average), and F(Failing). The results of this survey were compiled by assigning a value of 5 for "A" and 1 for "F". Figure 4 shows the results of VMI's April 2011 performance compared to the National Average with the survey results shown as a plus sign. The afternoon topics of surveying and materials were not included in the survey. There are clearly subjects where the cadets felt more prepared than their performance indicated. However, their overall perception of how well prepared they were for the different subjects approximately mirror their actual performance.

FUNDAMENTALS OF ENGINEERING CLASS

Although the attitude towards studying for the FE was improving, results from academic year 2011 indicated that there was still room for improvement. Based on improvements noted elsewhere [2], the CEE department decided to pilot a class to help cadets prepare for the exam. The intent of the class (CE 470) was to cover all topics covered on the FE exam and to emphasize the topics that are not covered in required classes. The class was offered as a three-credit technical elective in the fall of 2011 with 15 of 20 expected class of 2012 graduates enrolled. Offering the class for credit was a departure from the normal methods the department has used in the past. In order to meet for 42 hours prior to the exam, the class met during a normal Tuesday-Thursday class period and an additional Monday extended class period.

The class used preparing for the FE exam as a way "...to strategically review previously taken courses to regain knowledge learned, to learn basic principles in topics not specifically covered in the CEE curriculum, and to

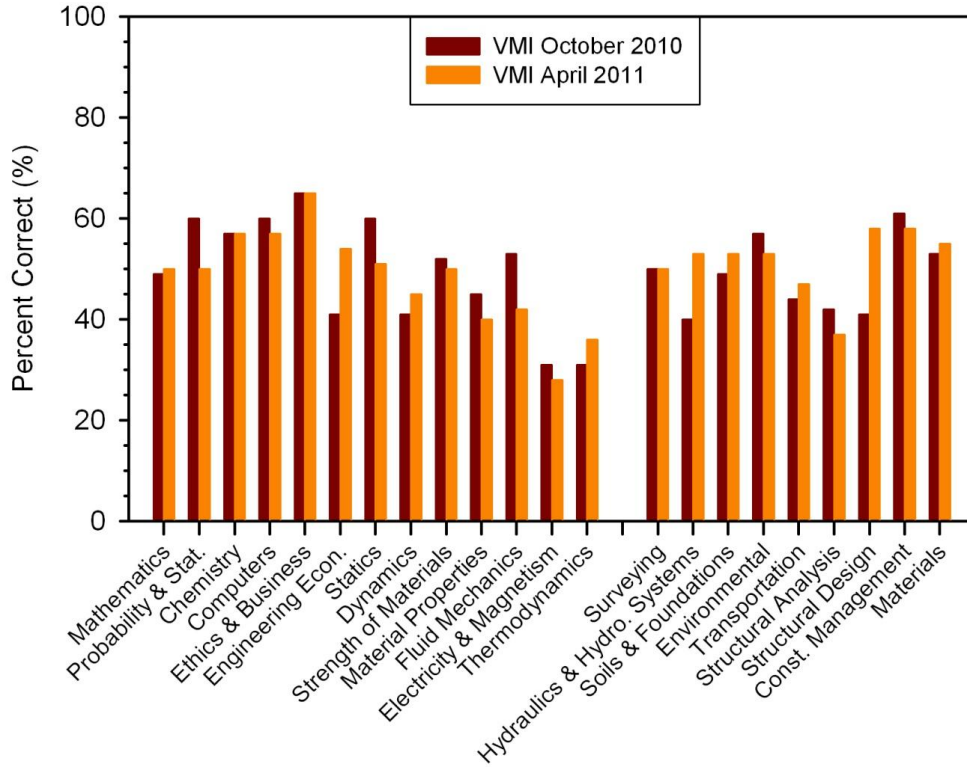


Figure 3 – VMI's Academic Year 2011 Performance

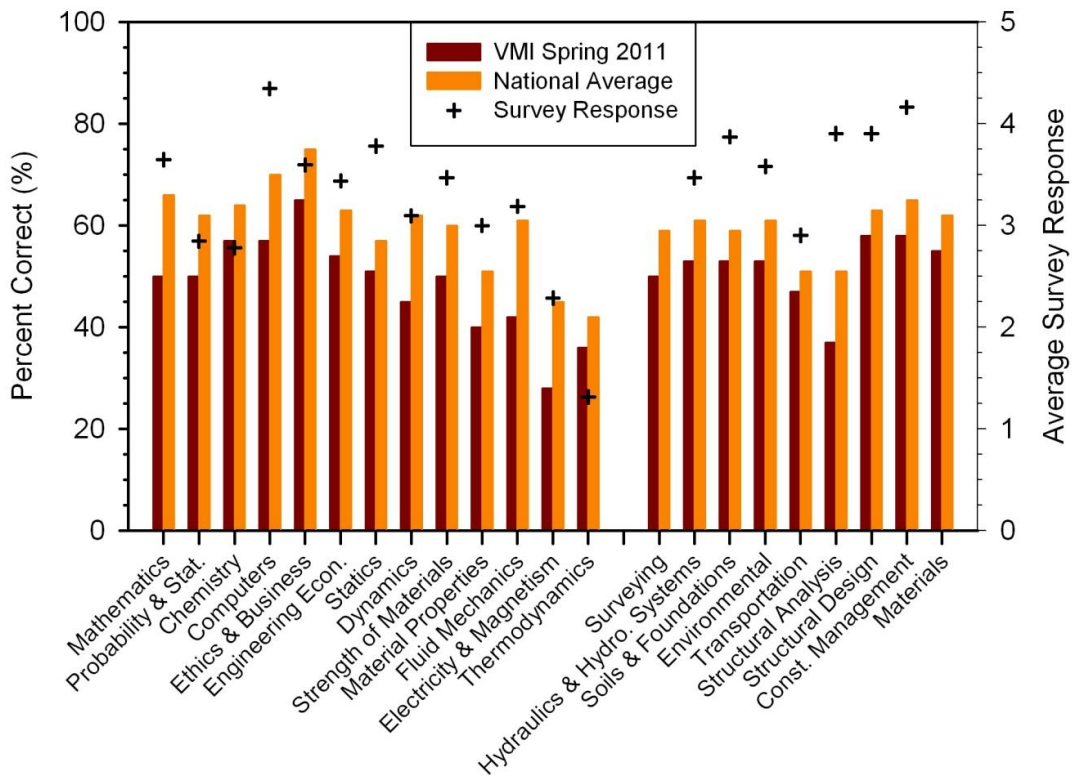


Figure 4 – Spring 2011 Results with Exit Survey

describe the engineering registration process and prepare for registration.”[4] Three different mechanisms were used to assess how cadets performed in the class. First, homework was assigned, collected, and graded. The grades were sometimes based on completion and other times based on both completion and correctness. Second, one or two quizzes per week were given using a class polling response system, commonly called clickers. The quizzes primarily covered non-quantitative concepts. Third, two-hour FE style exams were given for both the morning and afternoon sessions. The exams were designed to simulate the actual FE exam experience as much as possible including the use of Scantron® forms. Cadets were required to use an FE approved calculator and the FE Supplied Reference Manual as their only resource during quizzes and exams. Final class grades were based on points accumulated in all three areas. Similar to the FE exam, a modified Agnoff procedure was used to determine the final grades.[3]

The overall class experience was positive. Cadets entered the fall 2011 exam with a great attitude and a real desire to pursue professional registration regardless of their plans to commission. Results of the October 2011 exam were not available at the time this paper was written. However, in order to gauge the perception of their attitude towards the FE exam and the professional registration process, an attitude survey employing a Likert scale was created and given immediately following the FE exam.[5]

Results for the twelve cadets who took the exam are included in Table 1. Cadets were presented 25 questions to gauge their attitude. A scale using five categories was used for each question. The survey included only the words for the categories but point values were assigned as: Strongly Agree (5), Agree (4), Uncertain (3), Disagree(2), and Strongly Disagree(1). A statistical analysis of the questions was performed to determine the correlation of each question with the total attitude. This was done by computing the correlation coefficient r and the r^2 values for each question compared to the cumulative response minus the question being considered[6]

Table 1 – Results of Attitude Survey given at end of CE 470

Question	Avg. Score	r value	r ² value
CE 470 helped me become familiar with the FE Supplied Reference manual.	5.00	Undefined	Undefined
Passing the FE is important, even if I never become a professional engineer.	4.92	0.49	0.24
The CEE department supported my effort to pass the FE.	4.92	0.49	0.24
The time in class during CE 470 helped me to prepare.	4.92	-0.52	0.27
The format of the FE exam was as I expected.	4.83	0.61	0.37
I would like to become a professional engineer someday.	4.83	0.56	0.31
I would encourage other CE's to study to pass the FE.	4.83	0.32	0.11
Passing the FE may help me get a job offer one day.	4.75	0.58	0.34
I considered passing the FE a challenge that I wanted to undertake.	4.67	0.45	0.20
The practice exams helped better prepare me for the FE exam.	4.58	-0.42	0.18
The classes I took at VMI prepared me for the FE exam.	4.50	-0.40	0.16
I would have studied LESS if I had not taken CE 470.	4.50	-0.14	0.02
I learned new topics during CE 470.	4.50	-0.52	0.27
If I do not pass the FE this time, I will study harder for the next time.	4.42	0.31	0.10
My view concerning the importance of the FE has changed for the positive this semester.	4.25	0.53	0.28
Passing the FE will help me to make more money.	4.17	-0.44	0.20
Before college, I was an "Above Average" student.	3.75	0.19	0.03
I learned enough engineering economics in project management to be prepared for FE.	3.58	-0.25	0.06
I was often in the top 10 percent of my class.	3.50	0.50	0.25
Calc. and Diff. Eq. adequately prepared me for the math portion of the FE.	3.50	-0.02	0.00
Working problems alone was more useful than working problems in a group.	3.42	0.25	0.06
I prefer multiple choice exams over work out problems.	3.33	-0.34	0.11
I have always been good at taking tests.	3.25	0.57	0.32
I learned enough thermo, dynamics, and electrical theory in physics to be prepared.	3.17	-0.07	0.01
I have enough time in my schedule to study for the FE exam.	3.08	0.20	0.04

The results in Table 1 are presented in order of the average score, highest to lowest. A high score indicates “Strongly Agree” with the question. The high average scores on many of the questions show that the cadets had a positive attitude entering the exam. Most promising was the fact that the second highest score, 4.92 out of 5.00,

showed positive agreement with the statement “Passing the FE is important, even if I never become a professional engineer.”

It was hoped that the correlation coefficient, r , which can range from negative one to one, would provide useful information concerning the relationship of the attitude resulting from a given statement (the y variable) to the overall attitude of the respondents minus the given statement (the x variable). An r value of one should indicate a positive relationship while an r value of negative one should indicate a negative relationship. It was also hoped that the r^2 values, which indicates that percentage of the shared variance, would be useful to determine which attitudes varied the most. However, due to the small data set and the flatness of the data, the meaning for each is questionable.

Based on the responses shown in Table 1 and additional discussions with the cadets who took CE 470 and the October FE exam, attitudes certainly improved. The authors expect that these improved attitudes will continue to help improve the performance on the exam.

FUTURE OF FE PREPARATION AT VMI

The CEE department plans to review performance on the October 2011 and April 2012 exams before deciding how to help the cadets in the class of 2013 to prepare. The FE review course could be piloted one more time before seeking approval from the academic board to make it a permanent course. Whether or not it is appropriate to offer course credit for such a course will be the central issue discussed. This course will also be presented and discussed with external reviewers during VMI’s next planned ABET review which takes place in 2012.

At a minimum, the CEE department has learned that leaving exam preparation solely up to the cadets does not work at VMI. This is most likely due to time constraints which force the cadets to use their time to complete the most immediate assignment due. Changing attitudes has seemed to help cadets prepare for the exam, but they still need to set aside additional time to study. Offering the FE review course has succeeded in this endeavor.

POSTSCRIPT

Results from the October 2011 exam were released after the original paper was submitted. Eleven of the thirteen cadets who took the exam passed, producing a pass rate of 85%. This was one of the highest pass rates ever achieved at VMI. This helps to support the assertions made in the paper.

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