Professional Accreditation, Assessment, and Licensing: Fundamentals of Engineering Exam

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ABSTRACT: One of the most important phases of the registration process involves satisfactory completion of the Fundamentals of Engineering (FE) examination. This paper describes a FE review course which has been operating since 1980. The course has been successful in that 94.5% of the students completing the sequence have passed the Fundamentals Examination. The review emphasizes, over a seven-week period, the various engineering sciences. It is assumed that the students are motivated to study on their own the remaining material on the exam that includes, in part, questions on chemistry, computers and mathematics. A pretest, final practice exam, and independent student evaluation are also conducted. The findings indicate that well-motivated students, who complete a comprehensive review course, experience a high pass rate on the fundamentals of engineering examination.

For a university with an engineering program, performance by students on the FE exam can be important and may be utilized as one measure that outcomes are being satisfied. This can assist in satisfying ABET accreditation requirements. A state may also utilize the FE pass rate as an output measure of the effectiveness of an institution's undergraduate program.

1 INTRODUCTION

In order to protect the public, health, safety and welfare, the practice of engineering has been entrusted in the United States, by various governmental entities, only to those persons duly licensed and registered. Engineering has also been declared by government statute to be a learned profession, the practitioners of which shall be held accountable to the public for high professional standards in keeping with the ethics and practices of other professions (Engineering 1999).

Approved education, appropriate experience, and examination, commonly called the Three E's, are required in order to become a licensed professional engineer (P.E. 2002). This paper describes experiences related to the operation of a Fundamentals of Engineering (FE) review course designed to assist individuals to become Engineers-in-Training (EIT). Successful completion of the Fundamentals of Engineering examination may be considered one of the initial steps in becoming an EIT and subsequently a licensed professional engineer (Guidance 2000).

2 FUNDAMENTALS OF ENGINEERING EXAM

The Fundamentals of Engineering examination is composed by the National Council of Examiners for Engineering and surveying (NCEES) and administered in a uniform manner by the various boards of registration. It consists of required four-hour morning and afternoon sessions. The morning examination consisting of 120 questions and the afternoon general exam consisting of 60 questions is composed of multiple-choice questions covering the subjects listed below.

- Chemistry
- Computers
- Dynamics
- Engineering economics
- Electrical circuits
- Ethics
- Fluid mechanics
- Materials science/structure of matter

- Mathematics
- Mechanics of materials
- Statics
- Thermodynamics

The afternoon portion of the test consists of 60 multiple-choice questions in a specific area one of which a student must choose to complete. These include general, chemical, civil, electrical, industrial and mechanical engineering. In both parts of the examination all questions should be answered since no subtraction is made for incorrect answers (NCEES Fundamentals 1985).

It is usually recommended that a strategy be developed to prepare for the examination (Potter 1984). For example, some recommend that the general examination in the afternoon should be chosen since it covers the identical subjects as those on the morning test. It is also strongly advised to review subject areas with which an individual may be familiar but not to spend an exceedingly large amount of time on unfamiliar subjects. A knowledge and location of various formulas in the Fundamentals of Engineering Supplied – Reference Hand book is also recommended (Fundamental 2001). Copies of this book are available to students studying for the test. A new handbook is distributed during the exam since the examinees are prohibited from bringing their own copy for use during the examination.

An ASCE task committee has reviewed the FE exam in order to ascertain its applicability to B.S.C.E. programs (Fundamentals 1986). This was undertaken because results indicated that civil engineering (CE) examinees ranked 12th out of the 16 disciplines tested. In addition, only 60.6% of civil engineering students passed the examination compared with an overall 71.8% pass rate. After investigating the subject matter tested by the exam, the ASCE committee concluded that the FE examination measures those fundamentals appropriate for entry into the civil engineering profession and does not discriminate against civil engineers. It was noted, however that the poor CE performance was most likely related to the lack of student motivation to review for the exam.

This suggests that, nationally, civil engineering students apparently do not place a high priority on the FE examination. This may indicate that educators are not emphasizing to their classes the importance of the exam as well as the associated benefits and prestige of professional registration.

3 FUNDAMENTALS OF ENGINEERING REVIEW

In order to assist students in reviewing for the fundamentals of engineering exam, Lamar University has operated a comprehensive review course since 1980. The course has been successful in that over the years 94.5% of the students completing the sequence have passed the FE examination. Since 1986, a format which consists, of an introduction and pretest, seven four-hour review sessions, final practice exam, evaluation and independently directed study has been utilized. Before 1986 the syllabus did not include a pretest, evaluation, or independently directed study. However, in certain semesters due to university schedule requirements and various other factors the pretest is not offered. The data presented in this paper are based on the 1986 format which includes the performance of 364 students sitting for the FE Exam. It shows, specifically, that since 1986, the pass rate has been 94.0 %. This value is approximately equal to the overall pass rate since 1980, 94.5 %., which is based on the performance of 524 examinees.

The FE review is open to undergraduate and graduate students as well as engineers working in the community. It is composed, therefore of a large variety of students. The subjects covered in the review, consists of the following engineering sciences: statics, dynamics, solid mechanics, circuits, thermodynamics, engineering economy, and fluids. They are presented two nights a week (Tuesday and Thursday) for a seven-week interval. Faculty from five engineering departments; chemical, civil, electrical, industrial and mechanical, teach the course. Students who have confidence in their knowledge of a certain subject often elect not to participate in the evening that particular material is presented. In addition, it is assumed that it is the student's responsibility to review subjects such as chemistry, computers, materials, and mathematics. These subjects account for a large section of the required portion of the FE examination.

4 PRETEST

As the syllabus requires, all students enrolled in the course take a pretest (if it is offered) during the first week of class. The pretest is designed to familiarize individuals with the FE examination and to

indicate that a review session may be helpful in preparing for the exam. It consists of a collection of problems in the engineering science subject areas.

The average grade on the pre-test for the academic years since 1988-89 has been calculated. The results show that the pretest scores of students who passed the FE exam are roughly the same as those who did not satisfy all the course requirements including those who failed the FE examination. The average scores are 15.55 versus 13.02. It appears therefore, that all students tend to start the review course at a relatively low level of basic knowledge in the engineering sciences. These results suggest that it would be beneficial for the students to be involved in a review course.

5 FINAL PRACTICE EXAMINATION

After completion of the review sequence, a final practice exam is given. The final practice exam consists of a collection of problems similar to those utilized on the morning portion of the FE examination. It is believed that a score on this test should be a good indication of whether a student is adequately prepared to take the FE Exam.

The grade distribution on the final practice exam show that the scores of students who passed the FE exam are higher than the students who did not satisfy all the course requirements including failing the FE test. The average grade of those who passed the FE exam is 71.22 in contrast to 52.2 for students not satisfying all the requirements of the review course including those who failed the FE exam. The numbers suggest that numerous students have not taken the time to study and review for the final practice exam and/or the FE examination.

The average low score on the final practice exam is 56.71 for those students who passed the FE examination. The average grade for those who failed the FE test is 56.09. It appears that at this level a student's knowledge is such that he/she could possibly either pass or fail the FE Examination.

A previous study found that electrical engineering students performed at a relatively high level on the final practice exam compared to the other disciplines tested (Koehn 1989). Their average score was 76. In contrast, those in mechanical engineering performed at the lowest level with an average grade of 62. Civil engineering students were between the two extremes with an average score of 70 correct answers. This would suggest that, as a group, the majority of civil engineering students are capable, after a review, to perform well on the FE examination.

In this regard, the data relating pretest scores and the final practice exam is extremely variable. The findings suggest that the score on the pretest does not predetermine the performance on the final practice exam. Numerous students who do well on the pretest perform poorly on the final practice exam and vice versa. This is to be expected since most students study for the final practice examination but do not have the opportunity to review for the pretest.

6 FE EXAMINATION RESULTS

After completion of the final practice exam, a personal evaluation of a student's performance is conducted. Those subject areas which exhibit weakness are noted and independent study is recommended to correct deficiencies. This process has been found to be of great assistance in passing the FE examination. Overall, 77% of the students successfully finish the review course and sit for the FE examination. Since 1986, the passing rate for those students has been 94%.

The overall student grade-Point average (GPA) distribution discussed in a previous paper may be noteworthy (Koehn 1989). The data indicate that there is a direct relationship between grade-point average (GPA) and performance on the exam. As an example, all students with a GPA greater than or equal to 3.05 have passed the FE test.

As has been mentioned, 23% of the enrollees do not successfully complete the review course. Time constraints from required course work, interview trips, weddings, job assignments, work relocation, and other miscellaneous activities are given as reasons for not finishing the sequence. A number of these excuses may not be valid since the review is usually completed shortly after the midterm date and before pressure from required course work and finals tends to develop. It would probably be difficult, however, due to the aforementioned external and personal reasons, to substantially increase the completion rate above 85%. Nevertheless, the 94% pass rate on the FE exam suggests that the review course is meeting its desired objective. The passing rate by discipline is listed below

- Chemical 97.2%
- Civil 94.8%
- Electrical 93.2%
- Industrial 100.0%
- Mechanical 92.4%
- Total 94.0%

. As shown, since 1986, 94.8% of the civil engineering students have passed the fundamentals of engineering examination. This is significantly higher than the national average of roughly 60-70%. The data indicate, therefore, that engineering students, who are motivated to enroll in and complete a review course, are well prepared to satisfy the requirements of the FE Examination. This is also true for the other engineering disciplines.

7 ENGINEERING ACCREDITATION

There are various criteria that must be satisfied for an engineering program to be accredited by the Accreditation Board for Engineering and Technology (ABET). These are tabulated in the publication, "Criteria for Accrediting Engineering Programs" (Criteria 2003). One requirement that must be satisfied is that each program should have an assessment process including documentation that the results are being applied to further develop and improve the course of study. In addition, the outcomes that are important to the objectives of the program must be measured. Evidence that may be used includes performance on nationally-normed subject content examinations (Criteria 2003). The FE test is one such examination that may be utilized. Furthermore, an approach has been developed which may be utilized to measure a program's performance on various sections in the FE exam (Le Fevre 1999). The performance of Lamar University students on the FE examination is one indication that the program outcomes are being, to some degree, satisfied.

8 STATE REQUIREMENTS

The state of Texas has developed a testing mechanism at the elementary and high school level to measure and increase the performance of students in the public school system. At the university level, tests given by independent professional organization such as the FE examination are utilized as a critical measure of performance. By law, each state school with an engineering program must yearly report their pass rate on the FE exam to the Texas State Legislative Budget Board (House 2001). If the results do not meet a specific target, the reasons must be explained and plans must be developed involving the various steps that will be taken to achieve the target in future years. It is recognized that the results on the FE examination measure only those graduates who attempt the test. Nevertheless, it is utilized by the state as an indicator of the effectiveness of the institution's undergraduate engineering program.

9 CONCLUSIONS

There are numerous reasons for an individual to become a licensed professional engineer, including (Nedderman 1980):

1. Legal requirements (if appropriate)
2. Recognition by the public and peers.
3. Possibility of full membership and affiliation with various professional and technical societies
4. Recognition by industrial firms and government agencies

The aforementioned indicates that becoming a licensed engineer may be considered, by many individuals, a measure of professional development. This is a recognition for which numerous engineers strive.

For a university with engineering programs, performance by the students on the FE exam can be important and may be utilized as one measure that outcomes are being satisfied. This can assist in satisfying ABET accreditation requirement. A state may also utilize the FE pass rate as an output measure of the effectiveness of an institution's undergraduate program.

One of the initial and most important phases of the registration process involves satisfactory completion of the Fundamentals of Engineering examination. This paper describes a FE review course

which has been operating since 1980. The course has been successful in that 94.5% of the students (and 94.0% since 1986) completing the sequence have passed the Fundamentals examination.

The review emphasizes the engineering sciences covered on the exam. It is assumed that the students are motivated to study on their own the remaining subjects which consist of questions on chemistry, computers and mathematics. The engineering program at Lamar University requires the completion of a broad spectrum of courses in various subject areas. Since a large percentage of the enrollees in the review are Lamar students, this comprehensive background may also be a factor in the high FE pass rate.

The ASCE Task Committee on the FE examination has suggested that poor performance on the FE exam is related to lack of student interest to review for the test. This paper agrees with these findings and presents data that indicate that well motivated students, who complete a comprehensive review course, experience a high pass rate on the Fundamentals of Engineering examination.

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