Development of an Effective Learning Curriculum for the FE/EIT Examination

Uksun Kim
California State University, Fullerton
800 N. State College Blvd., Fullerton, CA 92834, U.S.A.
ukim@fullerton.edu

David Cheng[1], Othoniel Rodriguez-Jimenez[2], Ning Fang[3]

Abstract - **The main objectives of this research are to identify and investigate difficult concepts in the preparation and taking of the FE (Fundamentals of Engineering) /EIT (Engineering-In-Training) examination and to develop an effective learning curriculum to assist students in their mastery of the FE/EIT exam requirements and successfully continue in their engineer's careers. To achieve these main objectives, the following measurement activities will be performed prior to the development of an effective learning curriculum. (1) survey students who have taken the exam for the last 3 years; (2) compare the survey with data from NCEES (National Council of Examiners for Engineering and Surveying); (3) conduct a pre/post test survey of students who enroll in the program; (4) compare the passing rate with students not participating in the program, and compare the results with National Passing Rate from NCEES. The main contributions of this research project are to impact all engineering disciplines where students take FE/EIT exam and to assist students in passing exam and improving their post-graduation employment prospects. If this study is able to correct some misconceptions and the newly designed curriculum proves effective, a broad cross section of education may find the results relevant.**

Index Terms – Effective learning, EIT/FE exam Engineering practice, Misconceptions

INTRODUCTION

This research topic was developed during the RREE (Rigorous Research in Engineering Education) workshop held in July 2006 in Golden, Colorado. This five-day workshop was very intensive, practical, and informative and was funded by NSF (National Science Foundation). Throughout this workshop, four representatives from three different universities (two from California State University at Fullerton (CSUF), one from Utah State University (USU), and one from Polytechnic University of Puerto Rico (PUPR)) had a chance to exchange their own interests in the field of engineering education. All of them had the opportunity to approach the same questions regarding the importance of the FE/EIT exam (details about this exam will be explained later) for the engineering students' retention and their career after graduation.

Two key research questions related to the FE/EIT examination were proposed during the RREE workshop as follows: (1) How to identify and investigate difficult concepts in taking and preparing for the FE/EIT examination? (2) How to develop an effective learning curriculum to assist students in their mastery of the difficult concepts for passing the EF/EIT exam and beyond?

The first step to obtain answers for the above two questions was to perform a survey regarding the FE/EIT exam. Current engineering students were queried to establish specific research methodology based on the conducted survey results.

This paper is focused on this fundamental and critical step. The research results can impact all engineering disciplines where students take the FE/EIT exam and can assist students in passing the exam, thereby improving the students' employment prospects.

In this paper, several difficult topics concerning the FE/EIT exam were discovered from surveys conducted by not only three different universities but also three different areas of discipline including civil, electrical, and mechanical engineering. This survey was conducted during the fall semester of 2006.

WHAT IS THE FE/EIT EXAMINATION?

The FE exam is one of the essential steps for acquiring a professional engineer (P.E.) license. The FE exam

[1] California State University at Fullerton, dcheng@fullerton.edu
[2] Polytechnic University of Puerto Rico, orodrigu@pupr.edu
[3] Utah State University, ning.fang@usu.edu

was first offered in the 1965 by NCEES (National Council of Examiners for Engineering and Surveying) [1].

The FE (Fundamentals of Engineering) exam is the official name of this exam. Due to the characteristics of this exam, this exam is also called E.I.T. (Engineer-in-Training) exam. The official term, FE exam, will be used throughout this paper.

The FE exam is comprised of a 4-hour morning session (120 questions) and a 4-hour afternoon session (60 questions). For the morning session, the general exam is offered for all engineering disciplines. For the afternoon session, examinees can choose the general exam or a discipline-specific exam such as chemical, civil, electrical, environmental, industrial, or mechanical respectively. In this paper, the survey question is focused on the general exam format in the morning session because three different engineering disciplines are involved in this survey.

There are 12 topics in the morning session:

- Mathematics
- Engineering Probability and Statistics
- Chemistry
- Computers
- Ethics and Business Practices
- Engineering Economics
- Engineering Mechanics (Statics and Dynamics)
- Strength of Materials
- Material Properties
- Fluid Mechanics
- Electricity and Magnetism
- Thermodynamics

IMPORTANCE OF THE FE/EIT EXAM IN THE FIELD OF ENGINEERING EDUCATION

There are several important benefits for receiving a P.E. license as follows [2]:

- Only a license holder can prepare, design, and submit documents with drawings to public authority with signature and seal. Seal engineering work for public or private clients can only be officially performed by a P.E. license holder.
- Most employers are looking for licensed engineers.
- A P.E. license holder can be considered as a professional in one's own engineering field.
- Licensure is an indicator of the level of competence, dedication, potential, and integrity.
- A P.E. license holder may get some confidence and authority (officially) from the public.

It is obvious that passing the FE exam can be one of goals for the undergraduate engineering program. With the closer tie with one's own discipline through a licensure, it will definitely help to improve the retention rate and level of success in an engineer's career. As an educator in the field of engineering, it is very important to provide students with a specific vision of their future career and help them to obtain better job opportunities in the field of their specific disciplines. Without this kind of help, after graduation they may change their major not by their own decision but by serious difficulty in finding a proper job related to their undergraduate disciplines. The FE exam is the first step to acquiring a P.E. license. Most states provide no waiver for the FE exam as a qualification of PE exam. Thus, anyone who wants to get a P.E. license must pass the FE exam.

LINK TO THEORY

To develop an appropriate model of this research question, proper theory should be applied to the relevant framework. Four possible frameworks and relevant theories are listed below [3]:

- Learning framework: Information processing.
- Motivation framework: Task value, goal orientation.
- Developmental framework: Piagetian cognitive development.
- Conceptual framework: Disciplinary difficulties in learning, distributed cognition.

Among these four frameworks, conceptual framework is the most important thing to achieve the goals of this study because the main challenge of this study is how to develop an interdisciplinary curriculum covering the FE subjects efficiently.

CONTRIBUTION TO THE THEORY & PRACTICE

- Establish an effective model to address the fundamental misconceptions [4] of students who need to take FE exam.
- Improve students participating and passing rate & marketability.
- Assist with ABET outcome assessment [5] & [6].

SURVEY BACKGROUND

A total of 232 students participated in this survey. This survey was completely anonymous. 114 students were electrical engineering (EE) majors at California State University at Fullerton (CSUF). 73 students were civil & environmental engineering (CEE) majors at CSUF. 12 students were mechanical engineering (ME) majors at Utah State University, and 33 students were EE majors at the Polytechnic University of Puerto Rico (PUPR). This survey was conducted during the fall semester of 2006. Most students were undergraduate students (junior or senior – level), except all USU students, who were graduate-level.

A total of 11 questions were provided as follows:

1. What is your major?
2. How important do you feel is acquiring a FE license? (1 – 5)
3. How many times did you take the FE exam?
4. Did you pass the FE exam?
5. How many days did you spend preparing for the FE exam?
6. Which one is the most *comfortable* topic in the FE exam?
7. Which one is the most *uncomfortable* topic in the FE exam?
8. How did you prepare for the FE exam?
9. How many times did you attend FE review courses?
10. When did you or will you take the FE exam for the first time?
11. What is your GPA?

SURVEY RESULTS

The survey results are analyzed into two categories. One is related to general view and the other is related to exam-takers' view only.

I. Category 1: General View

- Importance of the FE exam

TABLE I
IMPORTANCE OF THE FE EXAM
(1: NOT IMPORTANT – 5: VERY IMPORTANT)

	1	*2*	*3*	*4*	*5*	*N/A*
CSUF_EE	6	11	18	29	50	0
CSUF_CEE	3	0	4	8	58	0
USU_ME	4	2	1	4	0	1
PUPR_EE	2	0	4	3	21	3

From table 1, 70% of EE students, 90% of CEE students, and 33% of ME students think that the FE exam is important (scale: 4 or 5). 13% of EE students, 4% of CEE students, and 50% of ME students think that the FE exam is not important (scale: 1 or 2). It is not easy to conclude that these results are related to ME discipline because there are only 12 students participated in this survey. However, we can conclude that most EE & CEE students think that taking the FE exam is very important.

- Attempts to take the FE exam

TABLE II
ATTEMPTS TO TAKE THE FE EXAM

	0	*1*	*2*	*3*	*> 4*	*N/A*
CSUF_EE	94	16	3	0	1	0
CSUF_CEE	40	32	1	0	0	0
USU_ME	2	9	1	0	0	0
PUPR_EE	31	0	1	0	0	1

In this case, it was reasonable to use CSUF_EE and CSUF_CEE data only. From table 2, 82% of EE students and 55% of CEE students did not take the FE exam. From tables 1 & 2, even though 70% of EE students think that the FE exam is important, actually 82% of them did not take the FE exam. In the case of CEE students, 90% of them think the FE exam is important, but 55% of them still did not take the FE exam.

From this result, we can observe that most students want to take the FE exam, but for some reasons are prevented from taking this exam. One of these reasons may be fear of some topics in the FE exam, and students think they are not ready to take this exam. To figure this out, the next two questions are related to the notion of comfortable and uncomfortable topics.

- Comfortable topics

TABLE III
COMFORTABLE TOPICS

	EC	*TD*	*Ch*	*SD*	*MP*	*Others*	*N/A*
CSUF_EE	91	1	5	3	1	8	5
CSUF_CEE	1	4	3	28	7	21	9
USU_ME	0	0	0	9	1	0	2
PUPR_EE	16	1	0	1	0	6	9

- EC: Electric Circuits; TD: Thermo-dynamics; Ch: Chemistry; SD: Statics & Dynamics; MP: Material Properties

For EE students, definitely 73% of them think "Electric Circuits" is the most comfortable topic. For CEE students, 38% of them think "Statics & Dynamics" is the most comfortable topic. Interestingly, 29% of CEE students think "Others" is the most comfortable topic and this topic may be "Mathematics". For ME students, 75% of them think "Statics & Dynamics" is the most comfortable topic.

- Uncomfortable topics

TABLE IV
UNCOMFORTABLE TOPICS

	EC	*TD*	*Ch*	*SD*	*MP*	*Others*	*N/A*
CSUF_EE	4	45	15	14	16	17	3
CSUF_CEE	15	30	6	1	2	8	11
USU_ME	3	1	3	0	2	1	2
PUPR_EE	2	14	2	1	2	3	9

- EC: Electric Circuits; TD: Thermo-dynamics; Ch: Chemistry; SD: Statics & Dynamics; MP: Material Properties

For EE students, 40% of them think "Thermodynamics" is the most uncomfortable topic. For CEE students, 41% of them think "Thermodynamics" is the most uncomfortable topic and 21% of them think "Electric Circuits" is the most uncomfortable topic. For ME students, 25% of them think "Electric Circuits" is the most uncomfortable topic and another 25% of them think "Chemistry" is the most uncomfortable topic. From this result, special review sessions should be

provided related to "Thermodynamics" and "Electric Circuits".

II. Category 2: Exam Taker's View

- Comfortable topics

TABLE V
COMFORTABLE TOPICS (EXAM TAKERS)

	EC	*TD*	*Ch*	*SD*	*MP*	*Others*	*N/A*
CSUF_EE	17	0	1	0	1	1	0
CSUF_CEE	0	4	2	13	4	10	0
USU_ME	0	0	0	9	1	0	0
PUPR_EE	0	1	0	0	0	0	0

- EC: Electric Circuits; TD: Thermo-dynamics; Ch: Chemistry; SD: Statics & Dynamics; MP: Material Properties

For EE students, 81% of them actually experienced no difficulty in the "Electric Circuits" topic. For CEE students, 39% of them experienced no difficulty in "Statics & Dynamics" and 30% of them experienced comfortableness in "Others" which may be "Mathematics". For ME students, 90% of them experienced no difficulty in "Statics & Dynamics".

- Uncomfortable topics

TABLE VI
UNCOMFORTABLE TOPICS (EXAM TAKERS)

	EC	*TD*	*Ch*	*SD*	*MP*	*Others*	*N/A*
CSUF_EE	1	12	2	1	2	2	0
CSUF_CEE	9	16	4	0	2	2	0
USU_ME	3	1	3	0	2	1	0
PUPR_EE	1	0	0	0	0	0	0

- EC: Electric Circuits; TD: Thermo-dynamics; Ch: Chemistry; SD: Statics & Dynamics; MP: Material Properties

For EE students, 57% of them actually experienced difficulty in "Thermodynamics". For CEE students, 48% of them experienced difficulty in "Thermodynamics" and 27% of them experienced difficulty in "Electric Circuits". For ME students, 30% of them experienced difficulty in "Electric Circuits" and another 30% of them experienced difficulty in "Chemistry". These results are consistent with the results from the general view. Review sessions should be adjusted to each discipline or additional sessions related to specific topics should be provided [7].

- Preparation method

TABLE VII
PREPARATION METHODS (EXAM TAKER)

	Self-study	*FE review course*	*No study*	*N/A*
CSUF_EE	13	6	1	0
CSUF_CEE	24	0	9	0
USU_ME	4	6	0	0
PUPR_EE	0	1	0	0

Surprisingly, 80% of exam takers prepare for the exam by self-study or no study. Only 20% of exam takers join FE review courses for the preparation of the FE exam. Even though CSUF has no review course, but UCI (University of California – Irvine) usually offers review courses. The other two universities have review sessions. Thus, this survey result implies that most students may think that review sessions cannot provide sufficient help for passing the FE exam.

- GPA vs. Test Results

TABLE VIII
GPA VS. TEST RESULTS (EXAM TAKER)

	Self-study	*FE review course*	*No study*	*N/A*
CSUF_EE	13	6	1	0
CSUF_CEE	24	0	9	0
USU_ME	4	6	0	0
PUPR_EE	0	1	0	0

From table 8, we cannot get any reasonable and meaningful conclusions relating to GPA to test results, because 52% of exam takers are waiting for their test results (Their answer is "I don't know").

CONCLUSIONS

From this study, the following conclusions can be obtained:

1. Based on the survey results, most engineering students think that the FE exam is important and have an intention to take the FE exam; however, most of them actually did not take this exam. To improve the FE exam taking rate, more detailed and practical introduction about the FE exam and a well-organized review course should be provided to the engineering students.
2. From the survey, uncomfortable topics related to each engineering discipline can be found. Uncomfortable topics are "Thermodynamics" for EE and CEE students and "Electric Circuits" for CEE and ME students. Review sessions should be adjusted for each engineering discipline or additional review sessions related to specific topics should be provided.
3. Only 20% of exam takers participate in the FE exam review course. Further investigations should be performed to figure out the main reasons why 80% of FE exam takers did not attend the exam review course. However, it is obvious that there are urgent needs to develop a new FE exam review course which can provide effective help for passing the FE exam.

These research results will be applied to a new FE review course to be offered at CSUF in the near future.

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