Exploring the Engineering Profession-A Freshman Engineering Course

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Abstract

The engineering curricula for BS degree programs at The University of Texas at San Antonio (UTSA) were recently revised. The major objectives of these revisions were to improve the quality of the programs offered, increase student retention, and enhance the engineering student experience at the freshmen level. A common freshman course, "Exploring the Engineering Profession," was introduced into each engineering program's curriculum at UTSA. The course contains special features designed to enhance the educational quality at the freshmen level, improve student retention, and provide design experience. It is a first course in preparing students for future engineering practice. An assessment process is in place to evaluate the effectiveness in meeting course objectives. This paper will describe in detail the course content and present the assessment results.

Introduction

It is widely known that engineers are essential to both the private and public sectors in order to maintain a strong economy, and that it is in the national interest to vigorously pursue the development of domestic science, technology, and engineering workers from all ethnic and gender groups. If the United States is determined to remain competitive in a global, technology-based economy, there has to be a concentrated effort to convince more students to prepare for careers in engineering and technology.

All engineering programs have trouble recruiting and retaining students in the engineering field. Large attrition rates are experienced during the freshman year largely due to the fact that students do not develop a strong affinity to the engineering profession. This situation calls for development of new introductory coursework that will help students develop long term motivation to pursue engineering careers. At the same time, students need to understand the effort required to learn the skills required to successfully complete an engineering degree and prepare them for successful careers in industry. The courses at the freshman-engineering level must contain special features designed to enhance the educational quality of the materials presented, improve student retention, develop ethics and problem-solving abilities, and provide early design experience that motivates students to study.

The University of Texas at San Antonio (UTSA) is an urban, state-supported university. The College of Engineering offers BS and MS degrees in Civil, Electrical, and Mechanical Engineering. It also offers Ph.D. degrees in Biomedical Engineering, Electrical Engineering, and

Environmental Sciences and Engineering. The engineering programs at this institution have been instrumental in providing educational opportunities for under-represented minority groups. In Fall 2004, minority students in undergraduate engineering programs constituted 56.6% of the total enrollment (43.5% Hispanic, 4.9% African American, 7.8% Asian, and 0.4% Native Americans). Of the 498 freshmen engineering students in Fall 2004, 212 were undecided majors.

All undergraduate programs at UTSA, including engineering, follow the same admission policy. Like most urban public universities, admission requirements are minimal to provide broader public access to higher education. Therefore, for these institutions, students' educational experience and training at the freshman level are essential to their success.

In 1998, the engineering faculty at UTSA realized that student retention rates were very low.[1] Tracking freshmen and sophomore student data showed very poor retention rates. After one year only 49% of the Fall 1996 freshmen and sophomores continued in the program. Tracking the same students for two years, showed 37 % and 35% retention rates for 1996 freshmen and sophomores respectively. A study was conducted to determine the underlying cause of the high attrition rate and to develop strategies to correct the problem. The results indicated many factors contributing to high student attrition rates. These included inadequate advising, poor study habits, lack of motivation, and insufficient resources. All these factors contributed to academic failure and students transferring out of our engineering programs.

In 1999 the three undergraduate engineering programs revised their curricula. The major objectives of the curriculum revisions were to improve the quality of the programs offered, increase student recruitment and retention, and enhance engineering students experience at the freshmen level. The new curriculum added recitation hours to fundamental courses, improved laboratory experimentation, and enhanced the design experience. [2, 3] A new course was introduced at the freshman level to recruit, retain, and prepare students for an engineering education. The new curriculum was implemented in Fall 2000.

EGR 1303 –Exploring the Engineering Profession

A brief review of previously reported attempts to develop successful programs to attract and retain students in the engineering field shows that a primary objective must involve improving the curriculum. The new curriculum should be the primary tool to recruit new students and retain those enrolled beyond their first academic year. One of the studies provided clear indications that freshman and sophomore classes are critical in retaining students in the field of engineering.[4] Early hands-on projects which involve active learning and student participation appear to be very promising. Many engineering schools introduced design projects in their freshman courses to motivate and expose students from the beginning to the most exciting aspects of engineering. [5, 6, 7, 8, 9] However, since most of the design activities and engineering practice in general require a team approach, it is important that students receive training in team formation and group dynamics.[10, 11]

The three undergraduate engineering programs (CE, EE and ME) require a first-semester freshman course, EGR 1303–Exploring the Engineering Profession intended to begin the student's preparation for future engineering practice. The course format is a three-hour lecture with one-hour laboratory/recitation. The laboratory/recitation hour is limited to a small enrollment (25) that allows student/instructor interaction in problem-solving techniques. The total enrollment ranges between 250 and 275 students in Fall semester and 120-150 students in Spring semester. The enrollment during the summer session is around 50 students.

The first part of the course is used to advise students in proper course selection and prepare students for college life. Students are introduced to basic tools of survival in engineering programs. Topics include study skills, time management, teamwork, student ethics, and oral and written communication skills. The computer application aspect of the course is designed with the strength of current students in mind. Students are introduced to basic computer applications in engineering and communications. The second part of the course is designed to instill the principles of teamwork and teach students the basics of group interactions. Students majoring in various engineering disciplines are organized in groups to work together on various projects that include engineering design problems, ethics, and project management. Each project generates a report that has a research portion followed by analysis, solution, and conclusion. The projects conclude with each team making a public presentation in front of their peers. Each team's performance is evaluated by the audience and scored based on content and presentation.

Several design projects are available. These included redesign of a home appliance with at least three improvements, design of a cover for a student parking lot, or selecting of a team of specialists to lead the project "Mission to Mars." The third part of the course covers the professional side of engineering that provides extensive information and detail about various fields of engineering and their interrelationships. This is where students learn about engineering functions in different industries and better understand their roles in the corporate structure.

The quality of instruction is essential for successful results. The overall competence of the faculty can be judged by education, diversity of backgrounds, engineering experience, teaching experience, ability to communicate, enthusiasm for developing more effective programs, level of scholarship, participation in professional societies, and licensure as Professional Engineers. As stated in ABET's[12] criterion 5, faculty members are the foundation for major decisions regarding the curriculum. A faculty member with extensive industry experience, along with extended teaching experience and a proven enthusiasm for developing effective programs was selected to lead the effort to develop this course.[13] At least one faculty from each engineering discipline was assigned to this course to contribute to course development and ensure that course content met their program requirements.

Students in this course are exposed to real life engineering problems and receive first hand information regarding real products and projects, following them from the initial concept to the end user. They have the chance to realize the importance of developing leadership abilities as they are exposed to changing perspectives brought by ascending the engineering hierarchy and the corporate ladder in general. Occasionally members of the local engineering community are also invited to give lectures describing various branches of the engineering profession or interesting projects they are working on.

Course Objectives: Faculty representatives from each engineering program have established specific course objectives for each individual course in the curriculum. The course objectives are directly related to a set of program outcomes and hence to the program educational objectives. Each course syllabus provides information on how the course contributes to established program outcomes. It also identifies whether each course makes primary (1) or secondary (2) contributions to the program outcomes. The agreed upon objectives of the new introductory course were to:

1. Provide opportunities to clarify educational and career goals;
2. Motivate students to pursue engineering careers;
3. Deepen the student's understanding of career opportunities in electrical, mechanical and civil engineering;
4. Gain an awareness of professional engineering organizations (ABET, IEEE, ASME, ASCE, SPE, etc) and professional registration (PE);
5. Provide opportunities to explore professional and ethical responsibilities of engineers and how fundamentally important integrity is in society;
6. Expose students to contemporary issues facing engineers;
7. Learn basic engineering problem solving procedures;
8. Learn how to use computer-based tools, such as Excel, Word, etc;
9. Acquire effective written and oral presentation skills.

These objectives are intended to provide students with the knowledge that will enable them to select the appropriate engineering career path and to generate and sustain a life-long passion and motivation to pursue an engineering career. The lectures are conducted in part as formal presentations followed by informal question and answer sessions. The recitations are structured as a place to exchange ideas and information under the supervision of dedicated teaching assistants.

Course Content: The entire course is designed to create an atmosphere of support and belonging to a special group of professionals that have the ability to improve almost every aspect of life in our society. Among the main topics covered are:

1. Study habits and goal setting;
2. Research, library, and career services resources;
3. College of engineering advising resources, academic career planning, and recommended programs of study;
4. Use of computer-based tools in engineering;
5. Working in teams;
6. Introductory problem solving skills;
7. Basic written, verbal, and graphical presentation skills for engineering;
8. Introduction to design process;
9. Career opportunities in civil, electrical, and mechanical engineering;
10. Professional registration as an engineer;
11. Professional engineering organizations;
12. Contemporary issues in engineering;
13. Professional and ethical behavior related to engineering;
14. Introduction to Engineering Economics principles;

15. Introduction to Engineering Materials;
16. Introduction to Engineering Standards, Codes, and Symbols;
17. Guest speakers describing their engineering careers and experiences.

Since this is the first course to introduce students to the engineering profession and practice, it may be considered the one that will either convince them to select the engineering path for their career or scare them away. Based on ABET's Criterion 3 recommendations the course should contribute to program outcomes that develop student abilities to:

- communicate effectively through written, oral, and graphical presentations
- have an ability to work in teams to solve multi-faceted problems
- understand ethical and societal responsibilities of engineers
- recognize the need for life-long learning and continuing professional education
- use computer-based tools for engineering applications use computer-based tools for engineering applications
- identify, formulate, and solve engineering problems
- understand and contribute to the challenges of a rapidly changing society

Learning Communities Each semester approximatley 50 students participate in the Learning Communities Program (two section of EGR 1303 is reserved for the program) The mission of the Learning Communities Program is to assist students to develop necessary college skills and academic proficiencies and to instill in each student a sense of belonging to the greater university community. The program is designed to help freshmen make the most of their freshman year by co-enrolling 25 students in 2 to 3 of their core curriculum courses. This means that students automatically get to know at least 24 other students who will be in the majority of their classes. They know each others' schedules, they understand what their classmates are going through, and it is easier to form study groups outside of class.

Course Assessment

The course has an assessment process with documented results. The assessment of the course includes student performance measures, course objective surveys, and the course audit loop. The feedback cycle varies for each of the instruments. While some provide immediate feedback on student progress in achieving the outcomes and allow corrective actions to be made at the beginning of each semester, others require long-term analysis over several years.

Student Performance Measures: The primary performance measures used to assess whether students are achieving the Program Outcomes include graded homework, quizzes, exams, laboratory reports, project reports, and oral presentations. All assignments are evaluated based on a set of outcomes established for each subject. Oral presentations are reviewed by peers and teaching assistants for content and delivery. The final grade, which represents the overall assessment process, measures the student's ability to demonstrate the stated outcomes of the course.

Course Objective Survey: This survey assesses student opinions on their success in reaching course objectives. A survey instrument has been developed to obtain feedback from students regarding the course educational objectives and outcomes. The course coordinators were asked to develop a set of comprehensive and specific objectives for each of the courses in the curriculum. Course objective surveys are conducted close to the end of the semester.

The course objective questionnaires include a list of course objectives. They are followed by a set of questions seeking student opinions on their knowledge of prerequisite topics and their success in meeting course objectives.

The results of student course objective surveys provide instructors immediate feedback on learning objectives at the end of each semester. This allows the instructor to make adjustments and improvements to the course the following semester. The results of the course objective survey for Spring 2004 is presented in Table 1. Students had the following choices in response to questions on the survey: 1= definitely false, 2= more false than true, 3= in between, 4 = more true than false, and 5= definitely true. Table 1 shows the average score and the standard deviation for each question. An average score above 3.0 represents a collective positive attitude of respondents towards a particular question.

Table 1. Course Objective Survey Results, Spring 2004

No	Question	Ave. Score	Stand Dev
1	I have a firm understanding of different engineering disciplines	4.33	1.07
2	This course has helped you clarify my educational and career goals	3.93	0.81
3	I have received academic advice from staff at the University Advising Center	2.91	0.71
4	I have received academic advice from staff at the College of Engineering Advising Center	3.59	0.99
5	I have received academic advice from Engineering faculty	3.84	0.92
6	In this course, I have learned about UTSA's engineering degree requirements	4.67	1.39
7	In this course, I have learned about the importance of course prerequisites	4.64	1.43
8	In this course, I have learned about effective engineering communication skills	4.32	0.96
9	In this course, I have learned about engineering professional and ethical responsibilities	4.55	1.18
10	In this course, I have learned about engineering analysis methods	4.03	0.82
11	In this course, I have learned about effective team participation skills	4.43	1.10
12	In this course, I have learned about becoming a registered professional engineer	4.38	1.18
13	I am aware of UTSA's rules related to scholastic dishonesty	4.42	1.38
14	The recitation sessions in this course helped improving my communication skills	4.16	0.94
15	The recitation sessions in this course helped improving my teamwork skills	4.30	0.96
16	The recitation sessions in this course helped in learning the course material.	4.22	1.05

Course Audit Loop The course audit loop is the heart of the assessment process. It provides important diagnostic feedback for course improvement. Each engineering course has is peer-reviewed periodically by a set of faculty assigned to the course. The reviewing faculty members (course peer review subcommittee) are knowledgeable about the course. They include the course coordinator and two or three other faculty who are typically on the teaching rotation for the course.

It is important to emphasize that what is being audited is the course, not the specific instructor. For common engineering courses, including EGR 1303, each subcommittee includes one faculty from each of the engineering disciplines (CE, EE, and ME).

The course audit loop involves the review of two sets of documents: course notebook and course portfolio.

- The course notebook contains samples of students work (graded homework, exams, projects, etc.). Three examples of student work are collected in the course notebook (one high grade, one average grade and one low grade). Samples of course work will be collected once a year.
- The course portfolio contains a set of documents that are permanently maintained for the course. These documents include the results and analysis of the prerequisite quizzes, results and analysis of course objective surveys, grade distributions, and all previous assessments and recommendations by the group of faculty assigned to the course.

The course peer review subcommittee reviews all materials in the course portfolio and course notebook and provides feedback on topic coverage and on whether the course objectives have been met. The assessment of student performance in achieving the program outcomes is based on review of the materials included in the course notebook and course portfolio. Under the coordination of the department chair, program faculty members approve any major changes in the course content. The finalized changes are reflected in the course syllabus.

Faculty members discuss the curriculum in departmental meetings (ME related courses) or college meetings (for common courses in the college). Any curriculum changes are reviewed and approved by the Academic Policies and Curriculum Committees at the College and the University levels. After approval of changes, the modified curriculum is implemented in the appropriate courses and thus the feedback loop closed.

A critical item used in the analysis of the course is the student course survey. The key in terms of the portfolio audit is whether the survey data was analyzed and acted upon. The emphasis is not just a data collection and tabulation effort. For continuous improvement the course coordinator takes extra steps to analyze the data and formulate an action plan to address any item that receives an average score of less than the defined threshold number (3 to 3.5 on a 5 point scale). Therefore, the course portfolio contains a summary of the course objective survey questions and scores, as well as a course survey review and action form. The form identifies:

- items on the questionnaire receiving a low score
- a comment by the instructor from that term as to the most probable reason for the low score
- a proposed action that will potentially increase the score in the next term

A schematic representation of the course peer review and assessment process is shown in Fig.1. The examination of the materials in student notebooks and information in the course portfolio best represents the continuous assessment process and course improvement implemented by the engineering programs at UTSA. Each course portfolio is stored at a central location that can be easily accessed by course coordinators and reviewers. The information in the portfolio is updated at the end of each semester for all courses taught during that semester.

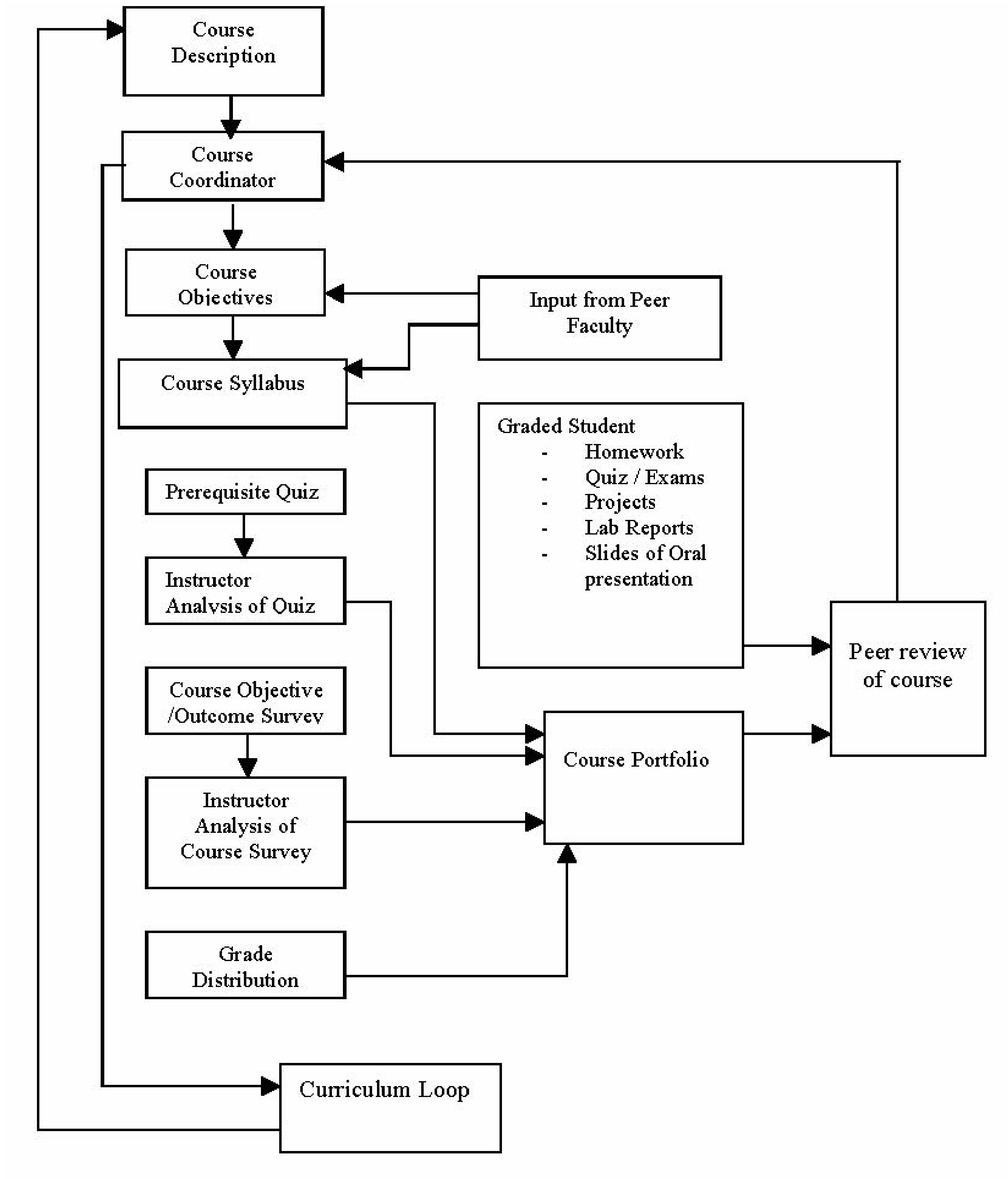

Fig.1. Course Audit Loop

Each course peer-review subcommittee reviews the portfolio and collected student notebooks. A course assessment rubric is designed and used in this assessment process. After reviewing the contents of the course notebook and the course portfolio, the reviewer assigns an appropriate score for each item on the form. Course contributions to the desired program outcomes are assessed and appropriate scores are recorded on the form. The scores are averaged for each item on the form. A threshold value of 3.0 (out of 4.0 points) is expected for the primary contributions to course outcomes; a threshold value of 2.0 is expected for the secondary contributions to designated program outcomes. The course coordinator prepares a short summary report for the course. If the average scores for program outcomes fall short of the expected threshold values, the course coordinator makes recommendations for corrective actions. The recommended corrective actions are acted upon at an appropriate level to ensure the achievement of program outcomes.

Conclusions

Efforts to infuse engineering courses with state-of-the-art technology and supplement the education process with a variety of interesting projects to motivate students to continue the study of engineering towards a Bachelor's degree have begun to produce the expected results. The degree of satisfaction expressed by students enrolled in this course is at an all time high and the attrition rates among freshman engineering students are at an all time low.

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Dan Dimitriu has been practicing engineering since 1970 and has taught engineering courses concurrently for over 20 years. He has been involved with several professional engineering societies, most recently as vice-president of the SPE -Central Texas Section. He has been the coordinator of the Engineering Program at San Antonio College since 2001 and adjunct professor at UTSA since 2004. His research interests are fuel cells, plastics, and engineering education.

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Amir Karimi is a Professor of Mechanical Engineering and an Associate Dean of Engineering at The University of Texas at San Antonio (UTSA). He received his Ph.D. degree in Mechanical Engineering from the University of Kentucky in 1982. His teaching and research interests are in thermal sciences. He has served as the Chair of Mechanical Engineering twice; first between 1987 and 1992 and again from September 1998 to January of 2003. Dr. Karimi has served on curriculum committees at all university levels and has been a member of the University Core Curriculum (1993-95 and 1999-2003). He is the ASEE Campus Representative at UTSA and is the current ASEE-GSW Section Campus Representative. He chaired the ASEE-GSW section during the 1996-97 academic year.