

## Innovative Approaches to Electrical Engineering Education

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### Abstract

This paper presents salient features of an innovative Electrical Engineering program started in January 2005 at the University of North Texas, Denton. This program integrates active “learning to learn” principles and project-based education with university-industry partnership, and entrepreneurship activities into our curriculum. The program is designed to prepare the students for: i) life-long learning, ii) strong design skills, and iii) professionalism and ethical awareness. For fostering life-long learning, we included in our curriculum a “learning to learn” course that is based on sound cognitive and pedagogical techniques to improve learning outcomes and facilitate development of life-long learning skills of the students. Our project-oriented course on ethics similarly seeks to provide them the decision-making skills required to resolve various ethical issues that they may encounter in their professional life. Finally, to achieve the objective of inculcating strong design skills in the students, we designed a curriculum with considerable project content throughout the program.

### Introduction

Rapid technological developments after the World War II led many educators to include in their engineering curricula more mathematics and science subjects with a view to facilitate the students’ learning of complex principles underlying the modern technology<sup>1</sup>. However, this important change in engineering education has come at the cost of many courses on engineering design, manufacturing and test methods<sup>2</sup>. This, in turn, resulted in the frequent criticism from both academic and industrial sectors about the inadequacy of the current engineering education in meeting the needs of the American industry<sup>3</sup> with respect to production of engineering workforce with skills in design and engineering practice. ABET (formerly The Accreditation Board for Engineering and Technology) put an increased emphasis on engineering design in its latest criteria. Particularly, the ABET criteria 3 (c) stipulates that the engineering

programs, must demonstrate that their graduates have an ability to design a system, component, or process to meet the desired needs. Further, numerous research reports on the superiority of student-centric and life-long learning paradigms<sup>4,5</sup> over the traditional teaching methods and the importance of ethics education<sup>6,7</sup> have influenced ABET to include these two criteria also among its requirements. Specifically, the ABET outcome 3 (i) states that the programs must demonstrate that their graduates demonstrate a recognition of the need for and an ability to engage in life-long learning. Similarly, the ABET outcome 3 (f) stresses on the requirement that the graduates have an understanding of professional and ethical responsibility. Our innovative Electrical Engineering (EE) program at the University of North Texas (UNT), Denton satisfies all the ABET outcomes from 3(a) through to 3 (k) and goes beyond in enhancing the student learning experiences.

## **Innovative Approaches in the program**

### **Development of Design Skills**

Our approach to developing student design skills contrasts with many previous approaches aiming to provide design experience to the students with one or two capstone project courses in the final year. We advocate that design thinking should be introduced early on and nurtured throughout the program. Hence we include project courses every semester in the program. These project courses are team-taught by our faculty and industrial adjuncts who bring forth real-life projects and best practices from the industry. Design-oriented regular courses along with the supporting project courses provide the design experience for the students.

### **Inculcating Life-long Learning**

To inculcate life-long learning skills in the students, we designed a project-oriented course on learning to learn (L2L). In this L2L course, they learn the cognitive principles and learning theories and assess their MBTI (Myer-Briggs Type Indicators) types. Above all, they learn how to manage their own learning.

### **Education on Ethics and Professionalism**

We strongly believe in the need for introducing ethics and professionalism to students as an integral part of our curriculum. Hence we introduce along with L2L, another project-oriented course on ethics and professionalism. Students take these two non-technical project courses in the freshman year while developing the required technical background to execute technical projects in the later years. This project course together with our emphasis on ethical responsibilities in every class prepares the students for ethical dilemmas they may encounter in a job environment.

### All-round Development

Our educational plan includes core technical subjects as well as humanities and social sciences that provide the students a well-rounded education. Particularly, the courses on English, technical writing, business administration, and cross-cultural, diversity and global studies provide the students with the skills required to perform well in the highly competitive job environments in the future.

### Education on Responsibilities and Self-awareness

In all our courses, we emphasize to the students the need to be responsible for one's own personal and professional development and a self-awareness of one's place in the social and professional environment and the responsibilities associated with it.

### Initial Phase of the Program Implementation- Some Sample Results

Initial assessment of the program suggests that the above features of program are motivating for the students. Our enrollment for Fall-2005 increased to 40 from 10 in Spring- 2005. The program being still in the stage of infancy, we do not have much quantitative data to provide statistically significant results on student learning. However, we could collect some qualitative data in terms of student feedback. The tables 1 and 2 below present some sample student feedback on our L2L and ethics classes last semester. Here, the students' comments are grouped into two categories: i) Appreciative comments, and ii) Constructive criticism.

**Table 1: Sample student feedback on our L2L course**

No.	Appreciative Comments	Constructive Criticism
1.	The class participation approach with thinking exercises in the L2L class was enjoyable.	More of unique and hands-on projects like the news paper tower and the thirteen pennies problems are needed.
2.	Liked the Rube Goldberg activity, the lectures on memory and learning processes, and the learning quiz to know my learning type.	Group effort should be more encouraged. For example, the second time we did a Rube Goldberg, it was in a small group but for a limited time.
3.	My favorite exercise was remembering words and pictures after seeing them.	More organized assignments will help to improve the course. We should have more group projects.
4.	Learning my own learning style was very interesting and illuminating.	There were too many problem solving exercises to complete.
5.	Liked the class participation stuff with thinking exercises.	A presentation on how engineers work, think, and live could help.

**Table 2: Sample student feedback on our ethics course**

<b>Feedback No.</b>	<b>Appreciative Comments</b>	<b>Constructive Criticism</b>
1.	Very interesting course that helped me to deal with some critical issues frequently arising in the society nowadays.	Could be more effective if the students get opportunity to work in an engineering company and have the first-hand experience of those issues.
2.	Very enjoyable class.	<p>Less time could be spent in the initial weeks on the discussion of the program as a whole.</p> <p>The tip on how to suggest to a junior colleague the need for improvement politely and professionally (e.g. you are doing good, but could do better) may not work on people like me who need clear-cut feedback on whether the way I am going is right or wrong.</p> <p>Discussions with smaller groups (3 or 4 people) could be helpful.</p>
3.	<p>Distinction between ethics and professionalism was clearly made.</p> <p>Case studies and eventual group discussions were very helpful.</p>	Discussion on the history of electrical engineering in the initial weeks could be replaced by more case studies. EE history warrants its own class.
4.	Teaching style and methods are very effective.	At the beginning of the semester, each student should be assigned a different case study to research upon. In each class, a student should present the case study and initiate a discussion. Each member of the audience must have a comment or question in each presentation.
5.	Very interesting part of the course was learning about patent issues from the real-life patent lawyers.	Prefer to have 2 1-hour classes instead of 1 2-hour class per week.

## Summary and Conclusions

This paper presents the innovative approaches used in the Electrical Engineering program at the University of North Texas, Denton. Since the program has just started, we do not have enough numerical data supporting the effectiveness of the proposed approaches. However, the subjective feedback from the students is very encouraging. We present here some of the sample feedback from our ethics and L2L classes. The constructive criticism is an indicator of the level of maturity of our students. It definitely helps us to continuously remodel our courses for the most fruitful results and make continuous improvements to our program.

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