

# **AC 2007-694: COVERAGE OF LEGAL AND ETHICAL ASPECTS IN ELECTRICAL AND COMPUTER ENGINEERING CURRICULUM**

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# **Coverage of Legal and Ethical Aspects in Electrical and Computer Engineering Curriculum (ABET Outcomes c and f)**

**Abstract** – Legal and Ethical aspects of engineering have been an integral part of the Electrical and Computer Engineering (ECE) curriculum at the Saint Louis University. The coverage of both legal and ethical issues begins at the freshman engineering course and continues throughout the four years. Various available resources in print and online are employed. Case study approach is adopted to bring about a better understanding of legal, ethical and professional responsibility. Accreditation Board for Engineering and Technology (ABET) requires engineering programs to include “an ability to design a system, component or process to meet with desired constraints .... “ (ABET outcome c) and “understanding of Ethical and Professional Responsibility” (ABET Outcome f) as two of programs educational outcomes. The ECE Dept. continuous assessment has shown achievement of desired performance levels for its Program Educational Outcomes.

## **Introduction**

The Department of Electrical and Computer Engineering (ECE) at the Saint Louis University is fully dedicated to undergraduate teaching and research. The department offers two degree programs in Electrical Engineering (EE) and in Computer Engineering (CpE). The Electrical Engineering program is ABET accredited. The Computer Engineering program will graduate its first class in two to three years. Both our programs are to be visited by ABET team in 2012. The department was established in 1987 by the generous support of local industry.

The Bachelor of Science in either of the programs offered by the department requires a minimum of 125 credits for graduation.

In meeting the program educational outcomes both programs place an important emphasis on the integration of legal, ethical and professional responsibilities throughout the curriculum. Coverage of such issues begins at the incoming freshman orientation (SLU 101). Professional and ethical responsibilities (ABET outcome f), engineering design process, and ability to design a product to meet desired needs within realistic constraints (ABET outcome c) are introduced in a required freshmen engineering course called “Introduction to Electrical and Computer Engineering” (EENG-101). Legal and ethical aspects of engineering are further emphasized in the sophomore and junior electrical engineering courses. As a major part of senior year experience ECE students are expected to be engaged in two sixteen week senior design course sequence, Design I (EENG-490) and Design II (EENG-491). Students are expected to be involved in major interdisciplinary design projects. In Design I and Design II various aspects of engineering design are covered. The resources available to the Saint Louis University community, such as speakers from two centers of ethics in Schools of Medicine and Business, and law professors from university law school, are employed to carry out workshops in ethical and legal issues. In addition, textbooks, published articles, and many resources available

online are employed to better educate our students of their legal and ethical responsibilities. The Online Ethics Center for Engineering and Science<sup>1</sup>, National Institute for Engineering Ethics<sup>2</sup>, National Society for Professional Engineers<sup>3</sup>, Applied Engineering Ethics Case of the Month Club, and various engineering professional society codes of ethics<sup>4</sup>, Law and Engineering<sup>5</sup> are among numerous resources available to educational communities.

### **Freshman Year Experience**

All incoming freshmen are expected to attend a day long university orientation. The day is used by faculty and staff to conduct several workshops to better prepare incoming students for their college experiences. Issues regarding ethical responsibilities, academic honesty, correct use of technology in completing assignments, accepting responsibility for one owns actions, and the university's mission as a Jesuit institution are covered.

Electrical and Computer Engineering Freshman students are required to register for a Freshman Engineering Course called Introduction to Electrical and Computer Engineering (EENG-101). A major part of the course is dedicated to introducing students to their chosen field of engineering and challenges and reward of the profession. Lectures are also dedicated to introduce design process and constraints such as technical, ethical, legal, economical, safety, and others. Department program educational objectives and outcomes are introduced. The importance of continuous assessment and improvement process is also discussed. ABET accreditation process is also covered.

Coverage of professional and ethical responsibilities of engineers begins by providing students with the Institute of Electrical and Electronics Engineering (IEEE), and National Society for Professional Engineers (NSPE) codes of ethics<sup>3</sup>. The importance of decision making based on ethics in engineering practices is taught using case study approach. Review of existing cases online emphasizes the importance of legal and ethical issues in of engineering practice. Cases in product liability and patent infringements are discussed. As a part of these exercises students are asked to review an existing NSPE case in ethics, and provide a written opinion identifying NSPE and/or IEEE codes of ethics relevant to the case. Then faculty shares the decision of the NSPE board on the case with students. The exercise provides valuable lessons on engineers' professional and ethical responsibility. An assessment of various teaching practices during the Freshman Engineering course provides valuable feedback to the continuous assessment and improvement process.

It should be noted that there exist great many online resources and in textbooks about the subject matter to assist faculty in their classroom lectures<sup>1-11</sup>. Great many universities also enjoy resources such as School of Law and Centers of Ethics that can be utilized by faculty to assist in teaching legal and ethical issues faced by engineers.

### **Sophomore and Junior Year Experiences**

Starting from the sophomore year, ECE curriculum gradually integrates more engineering courses as progress is made towards graduation. Ethics is further emphasized during the sophomore and junior year courses.

During sophomore and junior year students are required to take several laboratory courses. In great many of ECE courses individual and/or group term projects are assigned. Students' responsibilities in regard to data collection and reporting, safety and health of the public and use of resources (in print as well as internet) are further emphasized. An acceptable record keeping method in lab notebooks in relation to patent process is also introduced. Lab notebooks are collected regularly to provide feedback both on technical as well non technical aspects of data collection. Importance of record keeping and proper communication in a technical environment is further emphasized. A valuable case study in engineering communication has been the 1986 Shuttle disaster. The correct procedures used by the shuttle engineer in communicating his technical findings to his superiors are discussed. The covered materials in classroom provide a greater understanding of professional and ethical responsibility of an engineer. Surveys are one of many tools used to assess students' achievement levels.

All ECE students in their junior year are required to take a formal course in "Ethics and Engineering, PHIL-340". The course raises the moral and ethical issues that arise in the practice of engineering. Issues such as risk assessment, use of proprietary information, whistle blowing, environmental impact, and others are discussed in the course.

The evaluation of topics covered in engineering classes and a formal course in ethics has shown to meet and/or exceed desired level of achievement in our continuous assessment process.

### **Senior Year Experience**

The senior design experience at the Department of Electrical and Computer Engineering of St. Louis University is a two semester course sequence with sixteen weeks per semester. The total of thirty two weeks for the senior design courses is divided into three major sections of twelve-twelve-eight weeks. The end result of each major section is, in order, the preliminary design review (PDR), the critical design review (CDR), and the final design review (FDR).

A major part of the first twelve weeks is dedicated to forming multidisciplinary groups, project identification/assignment, and proposal development. During this phase various aspects of engineering design are covered as case studies. The design aspects covered includes legal, ethical, and environmental and others. In addition, practical design issues are introduced including cost, mechanical and electrical limits, packaging, resource allocation, and others. During the first week design teams are provided with a budget and additional project constraints.

During PDR workshops on Professional and Ethical responsibilities and Legal aspects are further emphasized. For ethical coverage a speaker from the one of the university centers

of ethics may be invited to act as a moderator for the workshop, or faculty may choose to adopt an exiting ethical case study for discussion. In the case study approach copies of adopted case is distributed to students in advance. Students are expected to carefully study the case and be prepared for discussion in class. At times students are assigned major characters in an adopted case to prepare for role play in the class. The practice allows students to appreciate complexities of decision making process. The exercise is an important part of increasing the understanding of students' ethical and professional responsibilities. It is made clear the importance of making decisions based on professional and ethical guidelines provided by various professional societies and NSPE. Students are tested and graded to evaluate their level of understanding and to provide feedback for further improvement of topical coverage. As a final exercise the answers to test questions are reviewed and the importance of the language used in codes of ethics is further emphasized.

Legal aspects of engineering profession are also covered in a workshop. A speaker from the School of Law and/or a local law firm is invited to make presentation regarding engineers and legal environment. Legal issue such as contracts, product liability, and patent process are presented. One of the first contracts most engineering graduate would be faced with is employment contract. As part of an exercise a legal employment contract was reviewed by our invited guest. Several recommendations are made to avoid legal problems at a later time. Patent process is another important area many engineers would be facing during their careers. Important topics related to patentability of a product and/or processes, steps in patenting process, disclosure issues, duration of a patent, and cost associated with patenting are covered. These types of legal exercises provide the opportunity for students to experience many of the legal issues/considerations faced by practicing engineers. Evaluation of students understanding of covered material is carried out in a quiz at the conclusion of the workshop. The results of the evaluation phase are used to provide feedback to further improve programs' stated outcomes and objectives.

Many aspects of engineering practice such as safety, environmental, political, social, economical are also discussed in various sessions as part of senior design experience. These exercises increase students understanding and their ability to be engaged in engineering design process to meet stated needs within realistic constraints.

Assessments of Students' "ability to design a system, component, or process to meet desired needs within realistic constraints" is based on their final oral and written presentations, as well as project demonstration. Practicing engineers from local industry and engineering faculty are invited to evaluate students' presentations and final designed product.

Senior exit interview and a comprehensive survey are also carried out. Various direct and indirect assessment tools are employed to measure the achievement level. The continuous assessment process has allowed us to make needed improvements so our students achieve acceptable performance level for program educational outcomes and objectives while meeting mission of the university.

## Conclusion:

The significance of legal, ethical and professional responsibility is emphasized throughout the electrical and computer engineering undergraduate curriculum. Several approaches are adopted to provide a more clear understanding of issues related to engineering design process. In this paper the process of incorporating coverage of legal and ethical issues in our curriculum is presented. Case study approach recommended by experts in the field, are employed as an important teaching tool. Students' achievement level may be evaluated using ethic's tests, case studies, legal reviews, exit interview, and a comprehensive survey. The uses of direct and indirect tools presented in this paper are few of many available tools in achieving desired performance levels for program/ABET outcomes "c" and "f".

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