

## The Engineering Leadership Development Minor at Penn State

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### ABSTRACT

Penn State's College of Engineering has begun anew, interdisciplinary minor to help engineering undergraduates develop the practical leadership skills they' 11 need throughout their careers. The Engineering Leadership Development Minor is sponsored by the Department of Electrical Engineering and the Leonhard Center for the Enhancement of Engineering Education, requires a minimum of 18 credits, and is open to students from all engineering majors. The focus of the Minor is to help students develop essential leadership skills, including ability to deal effectively with other people, to work in teams and to interact with customers on both national and international levels. Several new courses are being developed for the Minor, which began fall 1995.

### BACKGROUND

The idea for the Leadership Minor originated from discussions by the members of the Leonhard Center Advisory Board. The Leonhard Center for the Enhancement of Engineering Education was established at Penn State through an endowment by William and Wyllis Leonhard to catalyze changes in the engineering curriculum that reflect the educational needs of students who will practice engineering in the twenty-first century. The Advisory Board is composed of twenty distinguished Penn State engineering alumni.

The Advisory Board, in conjunction with College of Engineering faculty and administrators, developed the concept of a "World Class Engineer" who has, in addition to solid grounding in technical and scientific principles, the following attributes:

- International outlook
- Highly ethical orientation
- Innovative leadership skills
- Business savvy
- Strong communication ability

Would it be possible for students to be introduced to these attributes, given that engineering curricula in the departments are already full, on top of pressure to reduce credit hours?

The discussion led to the possibility of a minor in leadership development that engineering students could take along with their majors. Historically, engineering majors emphasized *depth*, examples being



environment and materials. - The subject matter of the world class engineer relates more to *breadth*, a unique twist for a minor. Since minors are sponsored by departments, Electrical Engineering became responsible for administration of the minor for the College, in partnership with the Leonhard Center.

Although the above and other relevant topics can be found in various courses offered at Penn State, it was felt that several new courses should be developed from an engineering perspective. Those courses and additional details related to the program are now described.

## THE PROGRAM

### Admission to the Minor

In order to qualify for the Minor, a student must have at least two years of study left at University Park, and successfully complete EE 408 (Leadership Seminar Series). An information session is held to ( 1 ) ensure that students are self-motivated towards developing leadership skills, (2) inform students about the Minor, and (3) brief students on the application process. Application includes a personal resume, transcript and personal interview. A final screening is conducted by representatives from the Electrical Engineering Department, the Leonhard Center, and the Leadership Development Minor Committee. Approximately 30 students are to be admitted into the Minor during the 1995-96 academic year.

### Course Scheduling

The new Minor was named "Engineering Leadership Development." It started fall 1995 and is open to students from all engineering majors. Initial enrollment was limited to 30 students, representing seven majors. A minimum of 18 credit hours is required for the Minor, and a grade of C or better is required in all Minor courses. Those 18 hours for the Leadership Minor are broken down in Table 1.

Table 1.

Courses required for Engineering Leadership Development Minor  
and Recommended Scheduling  
(Credits indicated in parentheses)

	Scheduling Recommendations by Semester Standing			
	1-2	3-4	5-6	7-8
Prescribed Courses (9 credits)				
EE 408 (1x2) Leadership Seminars for Engineers			X	X
EE 409 (3) Leadership Principles for Engineers			X	
STS 460 (3) Science, Technology, Society & Public Policy			X	
EE 495 (1) Internship Project				X
EE 407 (3) Technology Based Entrepreneurship				X



## Supporting Courses (6 credits)

Select 6 credits in consultation with the  
Coordinator of the Engineering Leadership  
Development Minor

X X

All of the EE-designated courses are new courses designed specifically for this program. Approval of EE hosting the Minor, and of those courses having the EE designation, by the EE Undergraduate Curriculum Committee and EE faculty, occurred following much discussion and debate. Subsequent approvals of program and courses were made at the College and University levels.

## Core Courses

The Minor is based on a sequence of core courses. Topics treated in those courses are indicated below. Some of the topics are similar to those found in business courses. The Minor does indeed address a number of “business” issues, such as marketing, finance, and strategic planning. However, these topics are addressed for the specific purpose of providing engineering students with contextual relevance.

The team teaching approach is used in this Minor. One of the most important skills that the Minor attempts to develop is the ability to work in teams, where different and often divergent attitudes and philosophies exist. This holds true for instructors as well. Instructors for the core courses of the minor include Ph.D.’s from engineering, education, and business. Since the team approach is such a critical aspect of the Minor, we feel that this sets an example of “walking the talk.”

### *EE 408- Leadership Seminar Series*

This is the lead-in course for the Minor and was offered during the fall 1995 semester. The course is intended to provide the opportunity to develop skills in key facets of leadership and to demonstrate how they relate to the engineering professional, and it makes extensive use of interactive learning techniques and team building.

#### Key Topics:

- Imaginative Brainstorming
- Diversifying Leadership Habits
- Tapping Stored Knowledge
- Ideas, How-to Statements and Serendipity
- Ten Myths of Creative Leadership
- Fear and Failure
- Innovating the Organization
- Leadership Tools for Innovation
- Using Intelligent Fast Failure
- Developing an Appetite for Risk
- Creating Persistent Success



A portfolio is required of each student. After each session of the course, an entry in the portfolio includes the following information:

. . . . .

- A brief summary of the topic discussed
- Opinion of the conclusions made in class
- Opinion of the speakers, their presentations and relevance to engineering leadership
- Where student has seen evidence of topic demonstrated
- At least three ways you can apply the topic

Guest speakers during the fall 1995 semester dealt with the following topics:

- “Professionalism in Presentation Skills”
- “Creativity, Leadership in the 21st Century”
- “Ethics”
- “Diversity, Multiculturalism and Stereotypes”
- “Entrepreneuring and Intrapreneuring”
- “The Synthesis of Leadership”
- “Creativity”

#### *EE 409- Leadership Principles for Engineers*

This course relates to the development of those skills important for professional engineering leadership. These include leadership models, leadership attributes, engineering project management, innovation, teamwork, product development, information technologies and flexible organization structures. Heavy emphasis is placed on team building and the case method.

Key topics:

- Project Planning
- Customers and Clients
- Opportunities in the Market
- The Marketing “Mix”
- Relationship Marketing for Engineers
- Competitive Analysis
- Quality
- Financial Concepts
- Project Budgeting and Control
- Project Evaluation
- Critical Path Methods
- Compliance Issues
- Purpose, Process and Strategy; SWOTS
- Envisioning the Future

A portfolio is maintained by each student. Eight case studies are performed by each group of students. A “Team Case Presentation” is made by each group on one of the case studies.



## *EE 407 - Technology Based Entrepreneurship*

This course was team taught during the fall 1995 semester by a Professor of Environmental Engineering and a Professor of Marketing. The course is predicated on the active learning concept in which students will learn entrepreneurship by developing new products for the market place. The target market is technological toys. Students work in teams designing, prototyping, machining, assembling and testing of the products.

Even though the target market is technological toys, there is no specific “product” that students in EE 407 construct. The intent of this course is to spark the collective creative imagination of teams of engineering and business students to create a real product. This product may have practical application, or it may be whimsical, but it is not the legendary “widget.” Student teams must put together a variety of things, including a competitive profile of the competing companies and products; pro-forma financial statements; a marketing plan; a prototype of their product; production drawings and a production plan; and a business plan for submission to the venture capital market. Other important things that the students “construct” are team building and problem solving skills.

### Key topics:

- Innovation process
- Idea generation
- Evaluation techniques
- New product development
- Prototyping design
- Concept testing
- Product testing
- Product quality
- Assembling resources
- Product costing
- Value pricing
- Paradigm building
- Going to market
- Developing business plan
- Contingency planning

## *EE 495- Internship Project*

Each student admitted into the Minor must complete a leadership internship project. The purpose of this project is to provide the student with an opportunity to apply the leadership skills developed in the various courses. Approval of proposed projects and project results is a joint effort of students in the Minor and instructors.

## *STS 460- Science, Technology, Society and Public Policy*

The course treats the all-pervasive importance of science and technology policy in modern societies



and the mechanisms and processes by which it is made.

Key Topics:

- Introduction to Science Policy
- Introduction to Technology Policy
- Economic Perspectives
- Political Analysis of S&T Policy
- Technology as American Religion
- Technology Impact on Values
- Technology and American Culture
- Ethics and Values in S&T Policy
- Funding S&T Government Laboratories
- Role of Universities
- Globalization of Technology
- Economic Valuation; Risk/Benefit/Cost Analysis
- Case Studies:
  - Technology and Jobs
  - U.S. Energy Policy
  - Defense R&D in Post Cold War Era
  - Pollution Control Policy
  - Food Laws and Regulations
  - Nuclear Waste Policy

Elective Courses

Six credits of elective courses are required. These can include courses in science, technology, public policy, management, psychology, sociology or other subjects, depending on the interests of a particular student. Some possible elective courses include the following:

- STS 200- Critical Issues in Science, Technology and Society
- ME/IE 297B - Product Dissection
- AIR 351 - Air Force Management and Leadership
- ARMY 402- Army Personnel Management and Logistics
- NAVSC 402- Leadership and Management
- PSY 441 - Industrial Motivation and Work Satisfaction
- MGMT 424- Interpersonal Relationships in Organizations

Program Administration

A commitment of resources was necessary in order to implement the Minor. These include a) one dedicated full time faculty for course development, administration and instruction, b) three part time (to the Minor) faculty for course development and instruction, and c) administrative support.

The program is administered by the Department of Electrical Engineering. Admissions, student files and



other program data are maintained by the EE Academic Affairs Office. Instructors for courses offered during the 1995-96 academic year are from the electrical (EE 408, 409, 495), civil engineering and marketing (EE 407) departments.

### Program Evaluation

The Engineering Leadership Development Minor was developed to satisfy the need for engineering graduates to be increasingly competent not only in their technical skills, but in areas such as communication, teamwork, ethics, innovation, international awareness and business practice. While it appears that the Minor courses can achieve these goals, the Minor's effectiveness - overall - should be more directly evaluated. Evaluations of each course and of the Minor are both of great interest and extremely difficult. Evaluation will be done at three levels: 1 ) the Minor core courses; 2) the Minor as a whole; and 3) post graduation evaluation.

For individual core courses, "development" of the students in the areas of presentation skills, ability to synthesize arguments and articulate their respective positions, and improvement in other "observable," will be apparent as the courses progress. Mid-course evaluations will be conducted to determine if students feel they are achieving the course goals. Instructors are encouraged to take action on student feedback. End-of-semester evaluations, normal for all courses, will also be conducted. A contribution related to evaluation will be requested from each student for the course portfolio.

It should be noted here that student feedback has already impacted EE 408 (Leadership Seminar Series), which was offered during fall 1995 semester as a one-credit course, meeting 50 minutes, once a week. Since students (and instructors/speakers) felt that this did not allow adequate time for discussion and group interaction, the course will be changed to a two credit course meeting two times a week for 1 1/2 hours each session.

For overall Minor evaluation, the Engineering Leadership Development Minor Committee is slated to meet twice a semester to review development and operation of the Minor, and recommend appropriate actions. Additionally, several instruments are being considered for use in overall evaluation of the Minor. These include the Arlin Test of Formal Reasoning, Cornell Test of Critical Thinking\*, Torrence Tests of Creative Thinking<sup>3</sup>, Ennis-Weir Critical Thinking Essay<sup>4</sup>, and Perry Model of Intellectual Developments.

While it is critical to evaluate the Minor's effectiveness while the students are at Penn State, it is just as critical to follow some sub-set of these students (and a control group) into their post-graduation jobs to find out how the Minor is affecting their work performance. This portion of the evaluation will focus on data gathering (questionnaires and interviews) with both Minor graduates, the control groups and their peers or supervision. We are interested in gathering not only the perspectives of our former Penn State students in terms of how their educations have prepared them for their current positions, but also their peers and supervision. The perspectives of their work associates will provide us with valuable data to validate and supplement what we learn from our graduates. Survey instruments are currently being developed.

It is also planned to evaluate employer response to the Minor indirectly by examination of job placement data. The placement rates of students completing the Minor will be compared to those of engineering students not in the Minor.



## SUMMARY AND OUTLOOK

A new Leadership Development Minor, suitable for students in all engineering majors, has been developed in Penn State's College of Engineering. The Minor requires 18 credit hours of coursework centered around active team-oriented learning, discover learning (over lecture) and collaborative teaching. Several new courses are being developed for the Minor, which also includes a number of relevant courses from outside engineering. The program started fall 1995, with initial enrollment fixed at 30, and with plans to increase to over 100. Initial student response has been very positive. Evaluation of the core courses and of the Minor as a whole will be critical as the courses and program are developed.

- [1] Inhelder, B., and J. Piaget. 1958. *The Growth of Logical Thinking from Childhood to Adolescence*. New York: Basic Books.
- [2] Ennis, R. H., J. Millman, and T. N. Tomko. 1985. *Cornell Critical Thinking Tests Level X and Level Z- Manual (3rd Ed.)*. Pacific Grove: Midwest Publications.
- [3] Torrance, E. P. 1967. *Journal of Creative Behavior* 1:137-154.
- [4] Ennis, R. H., and E. Weir. 1985. *The Ennis- Weir Critical Thinking Essay Test*. Pacific Grove: Midwest Publications.
- [5] Perry, W. 1970. *Forms of Intellectual and Ethical Development in the College Years*. New York: Holt, Rinehart, and Winston Inc.

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JEFFREY G. SOPER is Assistant Professor of Engineering Leadership and Director of the Engineering Leadership Development Minor. He received an M.B.A. from Columbia University, and a Ph.D. in Training and Development from Penn State. He is currently engaged in a large-scale engineering leadership competency assessment.

