# Developing Engineering Leadership Through an Undergraduate Minor in Management of Technology

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## INTRODUCTION

The development of Engineering leadership requires enhancing a wide range of capabilities within our undergraduate students. In the 21st century, the global economy and increasing levels of economic competitiveness facing our graduates suggest that issues of business and technology management are critical elements of this set. We have devised a minor program in Management of Technology to expand the perspective of engineering students.

Vanderbilt University's Management of Technology Minor program of study is designed to provide our students the opportunity to gain a working knowledge of the fundamentals of business and engineering management. The program is open to students majoring in one of the traditional undergraduate engineering programs offered within the Vanderbilt University School of Engineering (VUSE). Approximately one-half of the students graduating from VUSE assume some form of management position within five years after graduation. Babcock's 1989 study concludes that "two-thirds of today's engineers will spend two-thirds of their careers as managers". Clearly, engineering programs have a responsibility to prepare their students for management and leadership responsibilities.

Advisors selected from industry and academic sectors have assisted in our design of the Management of Technology Minor. Our design goal is to retain a strong technical education, centered on engineering fundamentals, as the primary focus of our traditional engineering programs. Industry expects engineering graduates to have such an education, and recruits from school that provide curricula best matching their needs. Parents and students also expect an engineering education to be grounded in discipline-specific fundamentals. Therefore, a balance must be maintained. This balance must recognize the growing importance of interdisciplinary activities and the great benefit of an understanding of some leadership, management, economic, and principles. These factors have guided our development of a minor program of study in Management of Technology.

## WHAT IS MANAGEMENT OF TECHNOLOGY?

At Vanderbilt, our working definition of Management of Technology is "an interdisciplinary program of study designed to give students the tools to competently manage technology development and innovation, to enhance manufacturing quality and productivity in a competitive international environment, and to implement these objectives successfully in the organization."

The successful development and implementation of advanced technologies will require scientific and engineering excellence, and also effective skills in the areas of technology leadership and management. Strategic planning, financial feasibility, the availability and cost of raw materials, innovative product development, human resources, project management, and the global competitive environment are example areas contributing to development of these skills. The National Research Council's report, "Management of Technology: The Hidden Competitive Advantage" documents this perspective. Technology-based organizations require leaders with the capabilities to competently manage research and development, product or process development, technological innovation and implementation. Today's corporations are increasingly aware that their executives and engineering managers need to understand the technologies on which their businesses are based and how to manage every facet of choosing and implementing these technologies in order to be successful.

Management of Technology links traditional engineering and management disciples to address the planning, development, and implementation of technological capabilities that can accomplish the strategic and operational objectives of an organization - typically a corporation or government agency. Academia has an opportunity, if not a responsibility to provide this linkage; other sectors have relatively minor efforts in this arena. For example, a National Research Council report evaluated the balance between research and development investments by U.S. industry and their investments in analyses of managing R&D efforts. The report found that, at the end of the last decade, $63 billion was spent on research and development, but less than $1 million on management of this huge effort.

The global competitive environment presents new and increasing challenges for effective technology management: new products and processes are developed and implemented at a rapidly increasing rate. Technology managers face shorter development, production, and marketing schedules for new products and processes, and simultaneously anticipate shortened product life-cycles. Successful leadership must respond with speed and flexibility. To compete in this environment, technical managers must not only understand the fundamentals of their business, but also the be able to recognize and respond to issues related to the development and management of an expanding range of technologies affecting their company.

## THE MINOR PROGRAM OF STUDY IN MANAGEMENT OF TECHNOLOGY

Vanderbilt's minor program of study in Management of Technology was developed to address these issues. The program consists of 15 hours of coursework, much of which may be taken as electives associated with the student's major program. Typically, only one or two additional courses beyond the normal degree requirements are necessary for a student to complete both their major and the Management of Technology minor.

Five courses are required. Of these, two are introductory courses, and three courses may be chosen from a list of elective courses. Each course in the program is three semester hours. A summary of program requirements follows:

**Program Requirements**

The student must take the following two courses.

MT214Technology, Business and Public Policy
MT215Introduction to Management of Technology

The student must select three of the following courses.

MT216Engineering Economy
MT227Applied Behavioral Science
MT230Technology and Human Values
MT231Principles and Management of Technological Innovation
MT242Technology Marketing
MT246Program and Project Management
MT275Technology Assessment and Forecasting

A description of each of these courses is provided in the next section.

Vanderbilt's Management of Technology Program reports administratively through the Department of Electrical and Computer Engineering, although the program draws teaching resources from the cooperation and support of faculty with an interest in engineering management from all departments within the Engineering School. (At Vanderbilt, programs and departments are organizationally distinct.) Program faculty are responsible for the curricular design and delivery of their program. The Management of Technology Program faculty hold primary appointments in VUSE departments according to their disciplinary expertise; their appointments to the Management of Technology program are secondary appointments. Adjunct instructors from industry and other institutions also serve as program faculty in Management of Technology.

**DESCRIPTIONS OF UNDERGRADUATE MANAGEMENT OF TECHNOLOGY COURSES**

**MT 214. Technology, Business, and Public Policy.** Technology, business, and public policies studied through the development of conceptual frameworks and their application to case studies. Examines the development of current technologies, their related industrial organizations, emerging technologies, and impact on business. Prerequisite: sophomore standing or above or consent of instructor.

**MT 215. Introduction to Management of Technology.** A study of the problems encountered by managers in the planning, organizing, and allocation of resources and in directing, and controlling technical activities. Prerequisite: junior standing or above.

**MT 216. Engineering Economy.** (Also listed as CE 216 and ChE 216) Economic evaluation and comparison of alternatives: interest, periodic payments, depreciation criteria, and analytical procedures in investment decision-making, plant feasibility, and cost estimating.

**MT 227. Applied Behavioral Science.** The "people part of management." Focus is on employees, customers, owners, and managers, with emphasis on skills and experience needed by young engineers to cope with management responsibilities in technical enterprises.

**MT 230. Technology and Human Values.** Provides the understanding necessary to engage in discussions and participate in decisions about the uses of technology by society. To achieve this requires an examination of moral problems arising out of the impact of technology on man. Readings and class discussions of important works in ethics and political philosophy are undertaken along with readings and case studies of the impact of technology on the individual and on society. Prerequisite: junior standing or above.

**MT 231. Principles and Management of Technological Innovation.** Principles of technological innovation presented and examined through case studies. The roles of industry, public institutions, users, and certain factors that facilitate or impede innovation are examined. Prerequisite: junior standing or above or consent from instructor.

**MT 242. Technology Marketing.** Marketing industrial and technologically-based products and services. Marketing activities from the inception of a product to end use are covered. Business marketing strategy, segmentation, distribution, and personal selling are explored through lectures, reading, cases, and individual student projects.

**MT 246. Program and Project Management.** Methods for planning programs and projects. Organization structures and information management for project teams. Communications between project teams and clients, government agencies, and others. Motivational factors and conflict resolution. Budget/schedule control. Prerequisite: junior standing or above.

**MT 275. Technology Assessment and Forecasting.** Methods of assessing technological changes in the social, political, ecological, economic, legal, and institutional environments. Technology forecasting is treated in detail: intuitive thinking, the exploration, the normative techniques of relevance and perspective trees, scenario writing, etc. Government and industrial reports are used as case studies and a term project is required. Prerequisite: junior standing or above.

## CONCLUSION

The development and implementation of a minor program of study in Management of Technology in the School of Engineering at Vanderbilt University has been justified and described. The program is designed primarily for undergraduate engineering students, who complete the program by proper choice of electives within their traditional engineering majors. This is the fifth year of operation of this minor program; it has been quite successful. The number of students participating in this minor program has grown at a rate of over 20% per year. The feedback from industry has also been positive. Engineering students with documented background in technology management (the successful completion of the minor in Management of Technology is noted on their transcripts) are generally more competitive in the job market after graduation. This program offers Vanderbilt undergraduate engineering students the opportunity to gain critical career knowledge in technology management and business principles while completing a four-year engineering degree in a traditional engineering major.

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