

An Integrated Model For Management and Economics Instruction for Engineers¹

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In today's global economy, the engineering function is more complex and multifaceted than conventional or traditional forms of organization. The organizations are continuously trying to adapt to changes not only in technology but also to changes in markets, regulations, financial innovations, changes in socioeconomic factors, and diverse work force (internally as well as externally). The computer and telecommunication revolution place technocrats in direct and closer contacts with internal workers, suppliers, competitors, and clients. Moreover, recent statistics show a significant shift of U. S. companies towards a more service-oriented global network and all these changing scenarios demand engineers with multiple roles of technology experts with efficient management skills. However, the technology education institutions have not focused on the need of educational training for our engineering or technology scientists to cope with their emerging role.

In a broader theme, this article is an attempt to project some thoughts on how educational background can be re-organized in order to better prepare today's engineering and technology scientists. More specifically, the article concentrates primarily on the combined effort of the School of Industrial Management and College of Science and Liberal Arts at the New Jersey Institute of Technology in re-designing the basic economics and management courses for our new technological and global society. The re-design is an attempt to develop joint curriculum for both courses with an emphasis on applications.

The paper proceeds in the following ways. First, we discuss the growing literature on the roles and required skills for engineers followed by the integrated management and economics instruction as part of integrating engineering and management education. In the third section, the paper discusses our experience of evaluating student knowledge in the fields of economics and management after taking the integrated course for one semester. Section four concludes the discussion.

II. Engineers and Skills in the Changing Environment

The role of today's engineers is significantly influenced by the business environment faced by manufacturing firms. The integration of a variety of business functions into multidisciplinary corporate units are crucial in order to survive in the global competitive market place. Moreover, technological advances, changing organization structure, and rising competition from newly industrialized countries [Porter (1986)] in markets also affected the career directions and expectations of many engineers. Increased concentration in cost efficiency and product differentiation may be the key to the new

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direction of the firms in order to regain or maintain competitive advantage [Porter (1985, 1990)]. Babcock and Lloyd (1988) however noted that engineers must link technical expertise with accounting and marketing personnel.

Lake (1992) believes that engineers need to have communication, interpersonal relations, negotiation, and conflict resolution skills in addition to technical skills. Omurtag et al. (1992) pointed out that finance, marketing, and human resource management skills are necessary along with engineering skill for engineering managers in order to accomplish the role of systems integrators. In a detailed study, Thamhain (1992) found similar conclusions where leadership and administrative skills are as important as technical skills for managing today's engineering function. The paper also contends that the understanding of the interaction of organizational and behavioral elements will play a significant part in integrating people from different disciplines and background into effective work groups.

Moreover, manager's personal styles must be conducive to the innovative, high performance demands from their engineering organization. Even in developing technical skills, among other things, an understanding of product market and consumers is important. Administrative skills, the components of multifunctional work planning process, modular and incremental planning, written and oral communications, resource planning, program measurements, motivational needs and self-forcing control, and administrative support staff are key to develop effective engineering managers. Kirchoff and Lin (1994) argue that current educational content in typical undergraduate engineering education contains few components of economic effectiveness and international competitiveness in marketing, finance, management and business strategy and demands bold changes.

Management Education and Engineers: Most engineering education programs still center on knowledge of technology [Lake (1992)]. The reason for this is both traditional and the criteria established by the Accrediting Board for Engineering and Technology (ABET); the accrediting organization widely used in the U.S. As regards the "humanities and social sciences," which can include traditional economics but not "subjects such as accounting, industrial management, personal administration, [or] engineering economy." Babcock and Lloyd (1992) stated that although ABET does not oppose management content in an undergraduate engineering program, management content has to compete with other courses and other program objectives for the unspecified 25% of a curriculum. Hauck (1992) and Kirchoff and Lin (1994) quoted ABET requirements and believe that the purpose of engineering training is limited to teaching students the application of theoretically based principles of the natural sciences to real problems. Hence students are expected to focus on one segment of a technology specialty. It is quite natural that these students will, after graduation from schools, become engineers involved mainly in technical concerns. Exposure to the overall topic of business, its management and its operations is difficult to communicate within the ABET approved four year curriculum.

A large number of ABET accredited engineering schools have adopted business management education requirements under an engineering management major [Sarchet and Robert (1992); Babcock and Lloyd (1992)]. Such programs, designed to link the gap between engineering and management knowledge, are typically housed in Industrial Engineering Departments and include many courses that stress technical aspects of management - production efficiency models, (e. g., method-time-motion studies), scheduling models, quality control, etc. that meet ABET's definition of applied technology. But these majors typically treat the subjects of accounting, finance, marketing, personnel management, and business strategy superficially, if at all.



The impact of changes in the global business environment upon engineering education has been fully appreciated by NJIT. In order to provide engineering students the integrated knowledge of engineering and management, NJIT has made some changes in its education programs. Firstly, at NJIT, students of conventional engineering programs may choose management as their minor field. In order to fulfill the requirement, these students will have to take 21 credit of managerial courses, which include the following seven courses: (1) Principles of Accounting or Accounting for Managerial Control; (2) Principles of Financial Management; (3) Management of Information Systems; (4) Principles of Management; (5) Principles of Marketing; (6) Management Science; and (7) Economics. If an engineering student takes another minor option in their undergraduate degree plan, they are still required to take at least one economics and one management course as a part of their social science and management requirements.

However, until recently, when engineering students enroll in traditional economics and management courses with business and social science students, the overall emphasis of teaching is somewhat abstract and typically reflects either social issues or financial corporate environments which are more suitable for social science and business related education respectively. Such courses, although comprehensive, fail to train engineering managers adequately in comprehending the practical management aspects of technology based companies. An initiative is underway at the New Jersey Institute of Technology to emphasize the inter relationship of the materials covered by the Principle of Management and Economics courses. These two courses have been re-designed as a joint curriculum in order to overcome the shortcomings of the traditional curriculum and teaching in these areas. This effort is part of a grant program from the National Science Foundation.²

In determining the appropriate curriculum needed for engineers in the real world, this paper has incorporated some of the key findings of Whittaker (1992) who conducted a questionnaire survey of engineers and engineering employers in industry and government regarding the appropriateness of curriculum topics. Of 52 potential topics, he found that oral communication; written skills; interpersonal skills; supervisory skill; industrial psychology; leadership theories; project management; interpersonal relations; time management; total quality management; and strategic planning were important criteria for successful careers. This initiative also includes some of the shortcomings in all categories mentioned above as well as topics in areas such as marketing, finance, management and business strategy usually ignored in engineering curriculum.

²The National Science Foundation (NSF) recognizes the importance of integrating engineering and management knowledge. A manufacturing education program, which aims at preparing engineering students to design, manufacture and sell products, was proposed by NJIT, funded by NSF, and is now under development. The proposed program integrates courses related to product design, manufacturing systems engineering and management. Besides, by offering seminar series conducted by industry experts and summer employment in manufacturing factory, this program also tries to provide students the experiences from the real world. The Dean of the Engineering College leads this education program initiative with key inputs from professors, students, and administration of all related disciplines in the institute.



Several features of the integration of the Economics and Management courses are noticeable departures from the previous teaching of the two courses. First, a scenario type game is played the first week in an attempt to establish a baseline of student knowledge in the field of management and economics. The same game is played at the end of the first semester sequence of the two course and is planned to be replayed at the end of the second semester. A detailed analysis of the findings is given in the next section. Second, where most texts and courses in economics end with the area of International Economics, the integrated course begins with the Global issues. For example, the introduction of supply and demand theories are applied to international trade and foreign exchange rates and the significance of trade as well as exchange rates, to managers is then demonstrated.

III. Assessment Approach of Integrated Curricula

In order to base an additional assessment of student achievement, regarding the new curriculum, other than classroom participation and testing, the following scenario was developed and presented to the students at the beginning of the first semester of the two-semester sequence of Economics and Management.

A manufacturer of plastic kitchen bowls and containers is not able to meet the market demand for its products; even though it has continually raised the price of its products. It is considering a major increase in production; either by a new plant in the United States or an overseas facility. The company has been very fortunate due to the fact that there have been many returns of its product because of defects; and yet, its sales still have increased. Despite its growing revenues, the company is in a precarious financial position due to its large debt-to-equity ratio. Also its Chief Financial Officer recently suffered a stroke and his position as yet remained unfilled. Fortunately, the company enjoys good relations with the employees and their union. A new three year contract with the union was just signed calling for wage increases equal to cost-of-living increases.

1. Discuss the various opportunities and problems facing the company (specially delineate the pertinent factors for each area under discussion).
2. What course of action would you employ for the company? Why? What are the bases for the decisions?

The students were primarily engineering students and all were either in the Freshman or Sophomore years. The students were divided into groups of four members each and worked on their respective analyses of the scenario and its attendant questions for a period of two weeks. At the last two weeks of the semester, the reports, which were collected, were given back to the groups. They were requested to make any changes, additions, deletions or revisions of any type that they might feel necessary in view of the semester's work.

The summary results of evaluating the student's reports are as follows:

1. Virtually all the groups were able to delineate the problems of
 - a. Poor quality control.
 - b. Loss of the Chief Financial Officer.
 - c. Large debt-to-equity ratio.
 - d. Inability to meet demand for its products.



2. Also, the strengths of the company were easily discerned by the groups; for example
 - a. Good employee relations.
 - b. Good union relations.
 - c. Union contract for three years held to cost-of-living adjustments.

The students were then asked what to do about the problems and what course of action should the company employ and what are the bases for their decisions. It is in this part of the analyses that the results were somewhat disappointing and yet enlightening. First, to the disappointment: the students readily recognized the problems; but their response to the problems was, at best, trivial. They all were appalled by the large debt-to-equity ratio and their solution to the problem was “that the large debt-to-equity ratio has to be reduced.” Or the students were equally dismayed at the large number of defects in the production of the products. However, only around 20 percent of the students were able to apply the theoretical aspects of the course such as elasticity of demand, costs of production, and different models of international enterprise and management, to the scenario. Based on our own scoring on the answers as they relate to the appropriate theory, we found that on average the class had a score of 74 or C which was less than our enthusiastic expectation.

It may well be that the course content is too demanding (e.g. the one semester covers both macro and micro economics along with inputs from finance and management). The management course sequence is also very ambitious as to content. Students are taught to think as a multi-function manager. First, they are trained to evaluate projects from a financial analyst’s perspective (cost-benefit analysis). They are taught also to think from the perspectives of a product manager and human resources manager in a global economy; employing management decision criteria during innovation and technical changes.

Each student is assigned a technology based industry as a case study at the beginning of the semester. As each segment of financial, marketing, and management theory is taught, students are asked to relate the issues to their respective companies through in class analysis, data gathering using SEC information available in the library, and in some cases through interviewing appropriate personnel. All students are required to analyze all aspects of the theory taught in the class to their projects; however detailed attention is given to one particular area of the materials covered in class (e.g. product planning or product marketing).

The students are given several basic financial valuation problems as home work assignments. A case study (similar to a Harvard Case Study approach) that tests a student’s ability to decide for a particular project whether management should lease machineries or purchase them is also included. Both projects are due at the end of the semester. These assignments are required in addition to the course tests of mid-term and final examinations. The course is team taught and at the present time; the instructors are assessing their first experience of the integrated model.

IV. Conclusion:

The combining of two courses, each given by a separate unit of a university is a bold and innovative advance in higher education. In this case - the Basic Economics course and the Basic Management course at the New Jersey Institute of Technology - have been integrated with a measure of success. Certain problems and challenges have arisen which will be met in the coming semesters



by redesign of course content and instructional materials, The emphasis of the integrated courses has been broadened to include manufacturing and industrial concerns as well as social and policy issues.

The faculty involved with the re-design effort has been continually required to assess the approach to the integrated courses as well as curriculum changes as the course work progress. As the integration proceeds in the forthcoming semesters, the integration will become somewhat of a natural process. We would be remiss if acknowledgement was not made to the National Science Foundation for their support in this pioneering effort. The returns to this educational program will accrue for many years to come and contribute to the education of American engineers in a profound and positive manner.

Appendix I
New Jersey Institute of Technology
Fall 1995 and **Spring** 1996
Economics & Management Topics For An Industrialized Society

Course Material

(Required) Economics, Samuelson, Paul and Nordhaus, R, Fifteenth Edition, McGraw Hill.

(Required) Management, Griffin, Ricky, Houghton Mifflin Company, 1993.

(Required) Financial Analysis, Notes Distributed by the Professors.

(Optional) Study Guides of the text books mentioned above.

Additional Reading Assignments and Solutions will be kept in the Library's Reserve Desk for your convenience.

Course Objective

The 1980s and early 1990s represented an increasingly problematic decade for manufacturers. Evidence suggests that the environment in the next decades is becoming even more challenging. Increased competition, globalization, and changes in technology and labor force is putting massive pressure on manufacturers to become more agile, responsible and flexible. This requires quick and efficient readjustment in product design, innovation and customization, responsiveness in delivery system, and continuous improvement in costing and marketing strategies. Such an environment demands a more integrated approach in training manufacturers and managers of the future.

With this in mind, this economics-management course sequence is intended to assist in identifying economic and management factors requiring and understanding of basic concepts as well as the ability to construct and evaluate alternative scenarios. The course will emphasize both economic and non-economic ramifications of developing and implementing manufacturing decision makings. It will attempt to integrate basic principles of economics, finance, and management with the realities of the market place. The course sequence will put special emphasis on management practices in the area manufacturing. A broad course syllabus is given below.

Week No 1

Module No. 1:

Group Based Simulation Game of Economic and Management Decision Making (First Round)

Week No 2-4

Module No 2:

Manufacturing in a Global Economy

Management Considerations: The Corporate Decision; The Global Marketplace; Assessing the International Environment; Types International Ventures; and Types of International Ventures; Economic Considerations: International Trade; Foreign Exchange; Hedging Risk; Balance of Payments; and Market Share



Week No 5-6

Module No 3:

Planning a Product

The Planning Function; The Focus and Elements of Planning; Coordinating and Preparing for Change; Developing Performance Standards; Setting Priorities and Objectives; Strategic Planning; Relating the Strategic and Operational Plans.

Week No 7-10

Module No 4:

Producing and Marketing a Product

Demand and Supply Concepts; Elasticity; Costs of Production; Law of Diminishing Returns; Economies of Scale and Scope Issues; the Firm and its Revenue Under Different Markets; Competition; Monopoly; Oligopoly; Marketing Process; Product Classification and Positioning; Market Segmentation and Distribution Channels; Pricing Decisions; Consumer Satisfaction.

Week No 11-13

Module No 5:

Basic Understanding of Finance and Markets

Financial Statements, Taxes and Cash Flows; The Balance Sheet; The Income Statement Corporate and Personal Tax rates; Ratio Analysis; Solvency, Efficiency, Profitability and Market Value Measures; Benchmarking; Introduction to Money and Capital Markets; Stocks and Bonds Characteristics; Investment Banks; Interest Rates Risk; Future and Options Markets.

Week No 14-16

Module No 6:

Cost-Benefit Analysis

The Time Value of Money; Simple, Compound, and Effective Rate of Interest; Uniform Series; Cash Flow; Opportunity Cost; Depreciation; Cost Benefit Analysis for Multiple Alternatives; Alternative Comparison Format; Ranking Mutually Exclusive Projects; Break-Even Analysis; Capital Budgeting; Net Present Value; Payback Rule, Accounting Rate of Return; Internal rate of Return, Profitability Index; Making Capital Investment Decisions; Tax Considerations; Cost of Capital; Concepts of Risk-Return; Approach and Determination of Sensitivity Analysis; Uncertainty, Expected Value, and Risk Analysis.

Group Based Simulation Game of Economic and Management Decision Making (Second Round)

Week No 17-18

Module No 7:

Business, Economy and Role of Public Institutions

Alternative Economic Systems; Free Market Economy and Role of Public Sector; Circular Flow Model; Unemployment and Gross National Products; Keynesian Economics; Fiscal Policy; Government Actions: Taxation and Expenditures; Concepts of Social Goods and Services; Money, Banking System and Monetary Policy; Banking System; Federal Reserve Bank; and Monetary Policy.

Week No 19-20

Module No 8:

Managing Manufacturing Innovations and Organizational Change

Strategy and Organizational Design; Corporate, Business, and Functional Strategy; Basic forms of Organization Design; Functional, Conglomerate, and Divisional Design; Emerging issues in Organization Design; Managing Information; Global Organizations; Nature of Organization Change; Managing Change in Organization; Changing Strategy; Changing Structure and Design; Changing Technology and Operations; Organization Development and Revitalization; Managing Technology and Innovation; Technology and Organization; Manufacturing Technology; R&D and Engineering Functions; MIS and



Knowledge Intensive Organizations; Creativity and Innovation; Creativity and the Innovation Process; Promoting Innovation in Organizations; Entrepreneurship and Organizational Culture;

Week No 21-23

Module No 9:

Managing the Manufacturing Firms in the 21st Century

Social and Ethical Responsibilities; Changing Expectations for Corporate Performance; Managerial Ethics; Ethics and

Social Responsiveness; Consumer Protection; Product Safety; Environmental Protection; Actions Needed to Implement Social Responsibility; Managing Cultural Diversity; The Impact of Diversity on Organizations; Diversity as Competitive Advantage; Diversity as a Source of Conflict; Antitrust Laws and Regulations; Consolidation of Firms and Competitive Markets

Week No 24-25

Module No 10:

Role of Motivation and Leadership in Manufacturing Process

Motivating Employee Performance; The Importance of Employee Motivation in the Workplace; Content, Process and Reinforcement Perspectives on Motivation; Goal Setting Theory; Japanese Approach; Using Reward Systems to Motivate Performance; Leadership and the Nature of Leadership Behaviors; Situational Approaches to Leadership; New Perspectives on Leadership; Political Behavior in Organizations

Week No 27-28

Module No 11:

Manufacturing and Physical Environment

Management and Environment; The External and Internal Environment; Bi-Products, Manufacturing Process, and Pollution; Understanding the Basic Pollution Consequences of Production Process; Waste Management; Concepts of Multi Life Cycle Products. Cost-Benefit Analysis Incorporating Pollution; Corporate Image and Revisit of Strategic Planning

Week No 29-30

Module No. 12:

Group Based Simulation Game of Economic and Management Decision Making (Final Round).

Course Outcome Assessment and Overall Review

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