ChE curriculum

ENGINEERING MANAGEMENT

A Course to Minimize Functional Handicaps of Graduates

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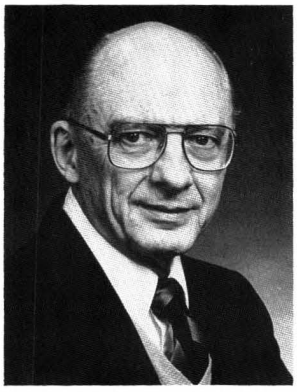
THE INDUSTRIAL ECONOMY in the U. S. has undergone significant changes since 1982. Some of the changes have been initiated by recent intensive overseas competition, some by the drop in oil prices, and some by mergers. In the 'right sizing,' or downsizing, that has taken place in most companies in this decade in order to maintain competitiveness, whole layers of management have been expunged. Other changes resulted from technological developments in the late 1970s and in the first half of this decade. Developments in computer workstations and software have added such power to the individual engineer that companies in chemical processing and the engineering companies serving them will never again need as many engineers of any discipline for the same volume of business as they needed in the 1975 era. As a consequence, there has been a reduction in hiring by most companies, with the result that many students have not been able to find jobs even months after graduation. Competition for the available jobs has become intense, and many young engineers have had to go into fields where they may never be able to use their hard-won training. The purpose of this paper is to review a course, "Engineering Management," that has been developed at the University of Oklahoma to improve the students' ability to get jobs and to perform better in any company.



Rex T. Ellington has been professor of chemical engineering at the University of Oklahoma for five years, after nine years at IGT (Illinois Tech) and nearly thirty years in industry. He received his BS (ChE) from the University Colorado and the MGT, MS (ChE), and PhD from IIT. He held research and general management positions in Sinclair Oil, Atlantic Richfield, and Transco Energy and had project management positions in Sinclair, Transco, Fluor Engineers and Constructors and Occidental. Along the way, he had a private consulting practice for a year. His teaching has concentrated on senior design, process control, and engineering management.

Important technical consequences of the industrial changes which were described in a recent article in this journal [1] agree with my own observations as a senior manager that

- **A smaller percentage of all engineers, especially in larger companies, will be able to move into management.**
- **All engineers will have to be more competent technically and to remain competent longer before they can become managers.**
- **While they practice their specialty, engineers will have to function more effectively in a company environment to have job security.**
- **Engineers will need far greater organization- and people-skills than past graduates possessed.**

The needs represented by the last item have been voiced by every industrial advisory group that I have known or been a part of in the last twenty years.

As soon as recruiters identify a lack of understanding of the industrial environment and an obvious lack of people-skills in interviewees, they lose interest. These graduates may never get an engineering job, or they may be shuffled aside at an early date. As recently as April 1987, senior managers advising our department told about students who were essentially unemployable, no matter what their GPA, because of their obvious lack of people-skills. The student needs to understand how the industrial world operates and should develop people-skills before leaving college so he/she can function effectively immediately after being hired. Costs are simply too high for businesses

to tolerate a one-year shakedown period for new engineers, as they did in the past.

Another educational need is based on the conviction of most senior managers that learning to manage is a lifetime job. This learning process must be started very early by engineers in order to meet the greater competition for managerial positions or they will be left behind, and business majors will skim off an even larger share of the top jobs in the future.

CHANGING THE CURRICULUM

C. T. Sciance [1] cites a significant need to augment the technical content of the chemical engineering curriculum, but it could be even more important to improve people-skills and knowledge of how industry functions. Many students gravitate toward engineering because their natural aptitudes lie more in math and science and less in communication and interpersonal relations. Throughout their engineering study this uneveness in skills probably increases. Students are shocked to find, while being interviewed or upon being hired, that the practice of engineering is a very people-oriented profession. They soon realize they are woefully unprepared in many areas that could affect career achievement even more than their calculation ability. A serious gap in their education soon becomes apparent.

The effects of the new employment environment have only lately reached the universities in the form of reduced job opportunites, but few changes have been made in the educational program in response to the needs of those now graduating and to the next generation of students. Why has the gap in organizational know-how not been filled? Many professors have no industrial experience, or it was of such short duration, or at such a junior level, that they do not know what is really involved and are uncomfortable trying to teach such material. They may agree with the need, but they lack the tools to deal with it.

An effort has been underway at the University of Oklahoma to develop a local solution to the problem for students willing to devote three semester hours to the effort, and to draft a text which could be used by other faculties. Further, we hope that the text might ultimately become a desktop reference which will be consulted more frequently than many technical references.

COURSE SPECIFICS

Ideas for this course have gestated for more than a decade, through thousands of goal-settings, performance reviews, hirings, firings, and many mistakes by the author. They came from fellow executives of all ages who urged that students be made aware of the things that cause so much difficulty in industry and handicap so many careers. Time and time again, the root causes of those difficulties are poor communication and lack of interpersonal relation ability, inadequate knowledge of company workings, or distorted concepts of management. Lately, new ideas have come as feedback from recent graduates.

The course then becomes one of high student-participation. Basic value systems are discussed to help the student understand why others react to life's inputs differently than the student himself does.

This is a course in what life is really like "out there." Many of the rough edges have been ground off. Attendance has been interdisciplinary, and the first results have been good. Feedback and requests from earlier graduates have resulted in the development of a text. Graduates have already reported on more comfort in working in team situations, a greater ability to determine supervisors' needs by quickly determining how an organization works, and less fear of moving into project work immediately. These results suggest that the effort is moving in the right direction.

The first draft of the text was developed to meet classroom needs and it is outlined in Table 1. The first part of the course is very important for the student and new graduate. It starts with a brief perspective of the entire course and then presents a view of the types of behavior and functioning expected of all employees. The characteristics of effective employees and good supervisors are discussed. There are numerous "horrible examples" to awaken the student to things that can happen which develop a bad reputation. The intent is to open the student's mind to the concepts that lead to being an effective person.

The course then becomes one of high student-participation. Basic value systems are discussed to help the student understand why others react to life's inputs differently than the student himself does. In the main, students seek the company of peers and cliques with whom they are comfortable. It is often a shock for them to realize that they may have to get along and work with people who see life differently. The value system is a convenient mechanism for identifying differences in reaction to one's environment.

Next, attention turns to getting a job—the right job for the individual. The student is taught how to take full, personal charge of job-finding. Careful assessment of the student's attributes leads to the de-

velopment of lists of job opportunities, location of target companies, investment of significant time on company research, and improved communication in resumes and interviews. Effort is expended to heighten the student's awareness of his/her impact on recruiters, interviewers, and other people during plant trips.

Then, important things that the newly employed engineer should consider in order to get the best possible start on the job are reviewed. These are obvious truisms, but they are often overlooked or ignored.

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Some of the most important areas concern the study of personal ethics, business ethics, technical and intellectual property of a company, liability problems (to give the student perspective regarding what must be protected), and obligations during and after employment. Then they examine one problem all of them will encounter some day in some way: whistle blowing. Moral obligations are analyzed in detail.

It is necessary to develop a different frame of mind in the students in order to attack the deficiency in communication ability which is mentioned by nearly all supervisors. Communication theory is examined briefly to learn why some of the best intentions go awry in speaking and writing. Throughout the course there are opportunities to make brief formal presentations, and each is critiqued by the class for its organization and delivery. At least one presentation is repeated several times in order to force the individual to revise and improve it. Written assignments are required frequently. The student is taught to observe audience awareness, whatever the occasion.

The true function of management is examined next and it proves to be a revelation for many students. As a result, some students are less anxious to become managers, but at the same time they develop a better appreciation of the needs of supervisors and managers. To help the student understand his/her new environment, subjects such as types of company organization, job descriptions, job evaluations, goal setting for individuals, performance reviews, and merit budgeting are taken up. Leadership types are examined in some detail so that young employees can better characterize the behavior of supervisors and work with individuals more effectively. Equal employment opportunity requirements are carefully discussed to help people avoid problems and/or to insure that their rights are observed.

The added awareness provided by these subjects makes the student a better employee. People who have had the course seem to get a faster start on the job and to have an edge on the competition—befitting the adage, "If at first you don't succeed, you may never." They are more aware of the importance of fitting into group activities, have greater empathy for a supervisor's needs, and are able to develop a personal program for advancement at an early date. The rate of return for the time and money invested in this part of the course appears to be very high.

MODERN TECHNOLOGY EMPHASIZED

The middle section of the course deals with modern methods of modeling, planning, and analysis. Techniques and sophistication vary widely from company to company, so the treatment provides a look at the utility of these tools without taking a course in operations research or a business course in modeling. Each method is examined from a management rather than a program writer's viewpoint, to show how the analyst and manager must work together and how model computer outputs or "decisions" are used. General economics and spreadsheets are reviewed quickly to provide the basis for economic decisions. Reading and analysis of company financial reports is stressed as an ability that every young engineer should have. The linear programming, which is one of the most widely-used optimization aids—from refinery operation to vegetable planting—is taken through graphical interpretation, matrix methods, analysis of computer outputs, and sensitivity studies. Study of integer programming provides the basis for analyzing supply, transportation, and other networks. Among these are the critical path and PERT techniques. Next, the student is presented with the structural basis for making decisions on a more rational basis. Decision theory considers the different paths electable in solving a problem and deals with the probable cost or consequence of picking each. Several types of business examples are used.

Reliability analysis is a field which the Japanese have adopted more widely than we have in the U.S. for a number of years. Failure, repairability, maintainability, and availability are taken up in terms of process plant units and design for reliability. This leads to consideration of risk analysis, fault trees, and failure mode and effect analysis. The fact that the rigor of the methods clarifies thinking is immediately clear. Results of these analyses do no good in the files,

however, and emphasis is placed on continued thinking by those involved in operations in order to prevent future catastrophes such as those which have occurred in the last decade.

By this time, students realize the limitations of deterministic inputs to models. Distributions are considered for input values, and Monte Carlo methods are applied to such things as cost estimates and sequential operation simulations. This section of the course provides a new awareness and perspective of tools most engineering students have not seen before. With this awareness comes the ability to help supervisors through the use of tools lacking in other engineers and the ability to sharpshoot with further study when the time comes.

PROJECT MANAGEMENT TOOLS TAUGHT

Since so many tasks in business and engineering are of a project nature, the third part of the course treats management of projects from beginning to end. Few young engineers know how projects get started; therefore, design bases, requests for proposals, proposals, contracts, and agreements are carefully reviewed and discussed to show that projects don't "just happen." A typical project is organized and engineering and detailed design activities are defined. Project activities and individual engineering discipline activities are related to total project progress curves, with emphasis on the interrelationship of activities. Probability of success on any project is related to the amount of planning, to the handling of details, and to the accuracy of measurements that go into it. All procurement activities (spec sheets, inquiries, bids, bid tabs, vendor selection, expediting, inspection, vendor data acquisition, and transport) are put into time perspective. Time and money control discussions involve activity definition, loading of effort on activities, critical path analysis, time and cost estimates, and cost control. Emphasis is placed on the need to measure progress in the same terms as the original estimate for accurate progress reporting. Product and service quality assurance needed for better reliability, maximum productivity, and lower costs in the face of overseas competition, provide background for treatment of construction or manufacturing and project completion.

At the end of this section, many students understand the unusual characteristics of good project engineers. Although they may not want to enter this specialty, they can function much more effectively on any project and realize the benefit of a project-manage-approach to their own lives.

TABLE 1
Table of Contents

CONCLUSIONS

Obviously, many topics are treated quickly, and not all are treated every semester. But the objective is perspective and development of the "big picture" viewpoint. With this, the young engineer knows where to dig when the need for details of a given method or topic arises. Over the years, the author has found that the engineer who has this perspective is most often the one who defines the problem correctly and comes up with the needed solution at the right time, *i.e.*, is the most promotable individual.

The chapter listing for the text is given in Table 1. Comments and ideas from educators or industrialists are always welcome. As a veteran project manager, the author's primary interest is improving the product and serving the customer (the student and the employer).

REFERENCES

1. Sciance, C. T., "Chemical Engineering in the Future," *Chem. Eng. Ed.*, XXI, No. 1, Winter 1987. □