普通高等教育“十一五”国家级规划教材
高等院校工业工程专业系列规划教材

Professional English for Industrial Engineering

工业工程专业英语

（修订版）

王爱虎 编

北京理工大学出版社
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内 容 简 介

本书系统介绍了工业工程的专业概貌和发展。本书内容基本上涵盖了工业工程的知识体系，兼顾介绍了基础工业工程和现代工业工程的理论和方法，也介绍了各领域的最新发展动态。全书共分五篇(21 课)，分别是：对工业工程的认识；基础工业工程；现代工业工程；工业工程前沿；工业工程展望。书末有专业词汇表。

本书既可作为本科生的专业英语课使用，也可作为硕士和博士研究生论文写作的参考用书。

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PREFACE 前言

尽管将近一个世纪以前起源于美国的工业工程管理理念在工业发达地区如欧美和日本等得到深入普及和广泛发展，但在中国真正受到重视却是最近几年的事情。计划经济向市场经济的转变，20余年的改革开放，国有、私营、合资和独资等多种经营方式的协调发展以及2002年末中国正式成为国际贸易组织（WTO）中的一员乃至十六大提出的新型工业化道路等为工业工程在中国的发展营造了良好的环境。与此对应，工业工程专业的本科、工学硕士、工程硕士和博士的教育和培养也受到了国家教委和全国多所高等院校的重视。2002年9月在北京举行的第九届工业工程和工程管理国际年会和工程硕士教学研讨会的不完全统计数据显示，全国有90多所高等院校已经开始了工业工程专业不同层次人才的培养。更可喜的是，2003年12月在上海召开的第十届工业工程和工程管理国际年会和工业工程（院）系主任联席会议上较为准确的统计数据显示这个数据已经增长到130多所。仅就工业工程领域的工程硕士教育而言，2004年全国报考人数为4 450人，实际参加考试人数为3 855人，而录取人数则为2 387人；同时2005年具有该领域招生资格的院校数量也由2004年的58个增长为66个。

国际竞争的加剧对工业工程专业人才的培养提出了更高的要求。未来的工业工程从业人员不仅需要掌握工业工程领域广博的专业知识，而且还应该具备同来自世界不同国家和地区、具有不同教育和文化背景的同行用英语进行专业沟通和交流的能力。而掌握大量的工业工程专业词汇无疑将对这种必要的沟通和交流起到巨大的促进作用。然而，目前国内关于工业工程专业的教材引进和编写正处于起步阶段，其中专业英语的教材尤为缺乏。这就是本教材的编写动机。

本书的目的可以简单概括为：为工业工程专业的学生（包括本科生、硕士生乃至博士生）、老师和从业人员提供一本系统介绍工业工程专业概貌和专业词汇的学习材料，通过专业词汇的集中学习提高其专业英语阅读能力和专业沟通能力。

本书有如下特点：

- 突出了对专业词汇的介绍，与普通英语的教学有很好的衔接；
- 内容基本上涵盖了工业工程的知识体系；
- 兼顾了对基础和现代工业工程的理论和方法的介绍；
- 在对工业工程基本概念、理论和方法介绍的同时，强调了各领域的最新发展

动态；

- 突出了工业发达国家的学者和从业人员对工业工程发展过程中经验的总结、思考和对未来的展望；
- 大部分内容选自高水平国外刊物，有很强的前瞻性，有利于高年级本科生、研究生乃至博士生的论文写作。

在本书的编写过程中得到了美国纽约州立大学布法罗大学工业工程系 Dr. Rakesh Nagi 和 Dr. Li Lin，香港中文大学赵先德教授，北京交通大学查建中教授和鄂明成副教授，河北科技大学李军教授和徐瑞园教授，重庆大学易树平教授，内蒙古工业大学陈红霞和华南理工大学工商管理学院徐学军教授等的支持，在此表示谢意！

由于作者水平有限，书中难免有不妥和谬误之处，恳请读者批评和指正。

编　者

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第一篇

对工业工程的认识

1 Industrial Engineering Education for the 21st Century
21 世纪的工业工程教育

The 21st century is just a few years away. Strategic planners all over the world are using the year 2000 as the focal point for future business activities. Are we all ready for that time? Is industrial engineering education ready for that time? As the industrial world prepares to meet the technological challenges of the 21st century, there is a need to focus on the people who will take it there. People will be the most important component of the "man-machine-material" systems competing in the next century. IEs should play a crucial role in preparing organizations for the 21st century through their roles as change initiators and facilitators. Improvements are needed in IE undergraduate education if that role is to be successfully carried out.

Undergraduate education is the foundation for professional practice. Undergraduate programs are the basis for entry into graduate schools and other professional fields. To facilitate this transition, urgent improvements are needed in education strategies. Several educators have recognized that the way engineering is practiced has changed dramatically over the years and an upgrade is needed in engineering education. Educators, employers and practitioners are calling for a better integration of science with the concepts of design and practice throughout the engineering curriculum. Such an integration should be a key component of any education reform in preparation for the 21st century.

Hurried attempts to improve education are being made in many areas. We now have terms like "total quality management for Academia," "just-in-time education," and "continuous education improvement." Unfortunately, many of these represent mere rhetorics that are not backed by practical implementation models. IE should take the lead in reforming its own curriculum so that it can help to develop practical implementation models that can be used by other disciplines. Many educators and administrators are searching for ways to transform improvement rhetorics and slogans into action. Models developed by IEs can provide the answers.

Quality in IE education

Incorporating quality concepts into education is a goal that should be pursued at national, state, local and institution levels. Existing models of total quality management (TQM) and continuous process improvement (CPI) can be adopted for curriculum improvement. However, because of the unique nature of academia, re-definition of TQM will be necessary so that the approach will be compatible with the academic process. For example, in industry, the idea of zero defects makes sense. But in academia, we cannot proclaim zero defects in our graduates since their success on the job cannot be guaranteed. Nonetheless, the basic concepts of improving product quality are applicable to improving any education process. Clynes, while reflecting on discussions he participated in at a National Research Council colloquium on engineering education, said "Teaching quality, like a company's customer service, can never be too good and always needs attention for improvement." This is true. A careful review of IE curriculum will reveal areas for improvement. This will help avoid stale curricula that may not meet the current needs of the society.

Theory and practice

Teaching determines the crux of research while research determines the crux of teaching. Integration of teaching and research is required for effective professional practice. The need to incorporate some aspect of practice into engineering education has been addressed widely in the literature. Pritsker recommends that professors must combine research interests with teaching responsibilities. The declining state of university education was described by Samuelson with respect to waste, lax academic standards and mediocre teaching and scholarship. These specific problems have been cited in the literature:

- Increasing undergraduate attrition despite falling academic standards at many schools. Decreasing teaching loads in favor of increasing dedication to research;
- Migration of full professors from undergraduate teaching in favor of graduate teaching and research;
- Watered down contents of undergraduate courses in the attempt to achieve retention goals;
- Decreasing relevance of undergraduate courses to real-world practice.

Curriculum integration

Curriculum integration (interdisciplinary approach) should be used to address the problems cited above. Curriculum integration should be a priority in reforming education programs. Students must understand the way the world around them works and be capable of becoming responsible contributors to the society. Interdisciplinary education offers a more holistic approach to achieving this goal. Interdisciplinary course and curriculum improvement should link separate but related subjects to provide students with comprehensive skills so they can adapt to the changing world. One form of interdisciplinary integration involves projects in which students from more than one academic department participate in joint industrial projects. This facilitates sharing of views from different angles.

Role of the IE

Enhanced IE education will prepare students to lead efforts to integrate entities in manufacturing and service organizations of the 21st century. The IE profession, as a whole, faces an important challenge in educating future IEs for this leadership role. The current IE curriculum provides good exposure to its many unique facets. Individual courses at both undergraduate and graduate levels in many institutions are comprehensive. Yet there are some fundamental deficiencies as discussed below.

The academic curriculum rarely emphasizes the fundamental philosophy of IE itself. That philosophy is a holistic approach to design, development and implementation of integrated systems of men, machines and materials. Students go through courses in operations research, manufacturing, human factors and so on without understanding the interrelationships between these areas and the synergistic impact this integrated approach has on man-machine systems.

IE is quickly losing its identity as a value-adding profession. The basic cause of this problem is that many IEs graduate without resolving the question of identity related to the following questions:

- What separates an IE from other engineers?
- What contribution does the profession make to an organization?

The root of this identity problem lies in the structured and isolated approach of various IE courses. This results in specialization that is too narrow. For example, graduates today tend to associate more with focused professional societies rather than the general IE. This is a disturbing drift that may destroy the identity of IE as we now know it.

There is a big difference between academic and industrial approaches to performance evaluation. The academic community evaluates its members by the number of publications and research grants. By contrast, industry measures performance in terms of real contributions to organizational goals. This has had a detrimental effect on the learning interaction that faculty and students must share for students to graduate with professional loyalty, technical competence and capability of integrating theoretical concepts and industrial practice effectively.

In the attempt to prepare students for graduate level education, the academic curriculum often has a strong mathematical orientation. Though a required approach, it develops a very structured approach to problem solving among students. Consequently, students expect all problems to have well-defined inputs, processing modules and outputs. Thus, when faced with complex, ill-defined, and unstructured problems that are common in the real world, many new graduates perform poorly. Chisman points out that the bulk of teaching should be done for undergraduate students since over 85 percent of them go into industry, not on to graduate school. Unfortunately, attempts to improve curriculum is often tilted in favor of research-oriented education, thereby depriving the majority of the students of the skills they need to survive in the business world.

Many young graduates mistakenly perceive their expected roles as being part of the management personnel, having little or no direct association with shop-floor activities. Such views impede hands-on experience and prevent the identification of root causes of industrial problems. Consequently, this leads to the development of solutions that are short-term, unrealistic, and/or inadequate. The growing reliance of simulation models that cannot be practically validated in real-world settings is one obvious symptom of this problem.

Like many other engineering curricula, IE is growing within an isolated shell. Students do not realize the importance of developing solutions beneficial to a system rather than for individual components. Many new graduates take a long time to become productive in developing solutions that require multidisciplinary approaches.

Ethics in education

Professional morality and responsibility should be introduced early to IE students. Lessons on ethics should be incorporated into curriculum improvement approaches. IE graduates should be familiar with engineering code of ethics so that they can uphold and advance the integrity, honor and dignity of their professions by:

- using their knowledge and skill for the enhancement of human welfare;
- being honest, loyal, and impartial in serving the public, their employers and clients;
- striving to increase the competence and prestige of their professions;
- supporting the professional and technical societies of their disciplines.

Some points to consider when developing curriculum improvement approaches are:

- Education should not just be a matter of taking courses, getting grades and moving on. Lifelong lessons should be a basic component of every education process. These lessons can only be achieved through a systems view of education. The politics of practice should be explained to students so that they are not shocked and frustrated when they go from the classroom to the boardroom.

- Universities face a variety of real-world multi-disciplinary problems that are often similar to industrial operations problems. These problems could be used as test cases for solution approaches. IE students could form consulting teams and develop effective solutions to such problems.
- Schools should increase their interaction with local industries when such industries are available. This will facilitate more realistic and relevant joint projects for students and industry professionals.
- The versatility of IEs in interacting with other groups in the industrial environment can be further enhanced by encouraging students to take more cross-disciplinary courses in disciplines such as mechanical engineering, computer science, business, etc.
- Students must keep in mind that the computer is just a tool and not the solution approach. For example, a word processor is a clerical tool that cannot compose a report by itself without the creative writing ability of the user. Likewise, a spreadsheet is an analytical tool that cannot perform accurate calculations without accurate inputs.

Curriculum assessment

Performance measures and benchmarks are needed for assessing the effectiveness of IE education. The effectiveness of curriculum can be measured in terms of the outgoing quality of students. This can be tracked by conducting surveys of employers to determine the relative performance of graduates.

The primary responsibility of a curriculum improvement team is to ensure proper forward and backward flow of information and knowledge between the academic institution and industry. The percentage of students passing the engineer-in-training (EIT) exam can also be used as a performance measure. The percentage of students going on to graduate programs and staying on to graduate will also be a valuable measure of performance. Entrance questionnaires and exit questionnaires can also be used to judge students' perception of the improved curriculum.

Conclusions

Significant changes are occurring in the world. These changes can come in terms of technological, economic, social and political developments. To adapt to these changes and still be productive contributors to the society, IE students must be prepared to be more versatile than their predecessors. This preparation requires significant changes in the contents and delivery of IE education. Educators and administrators institute plans immediately for reforming IE education in preparation for the landmark expectations of the 21st century. Efforts to improve IE education now will eventually lead to the development of leadership roles that other disciplines can emulate. This is a worthwhile service to the whole society that IE educators and professionals should not overlook.

Professional Words and Expressions

Industrial Engineering	工业工程
Total Quality Management	全面质量管理
Continuous Improvement	持续改进
Human Factors	人因学,功效学
Man-Machine Systems	人机系统
Shop-Floor Activities	车间活动
Simulation Model	仿真模型
Code of Ethics	道德标准,职业准则
Performance Measure	绩效测量
Benchmark	标杆

Discussion Questions:

1. Browse through the Internet and find the IE curriculum of three universities, in which you are interested the most, at the undergraduate and graduate levels respectively. What features do they have and how are they different from the curriculum of your university?
2. How is the IE education quality guaranteed in your university?
3. Search either the Internet or your library to find the evaluation metrics of the IE education at undergraduate and graduate level separately in China. What are your comments?

编者注

2003年12月6日至8日于上海交通大学召开的中国机械工程学会第八次工业工程年会的相关资料显示:目前我国有120余所高校已经开始了工业工程专业的学士、工学硕士、工程硕士乃至博士的教育和培养。考虑到我国将成为21世纪的全球制造中心,市场对具有高水平工业工程素质的复合型人才将有较大的需求。有理由相信工业工程专业的教育将成为我国继MBA教育后的又一个亮点。然而,我国工业工程专业的教育体系还处在逐步建立和健全之中,培养方案的设计、实验室的建设、核心课程的确定和开发、教学环节的把握、论文研究的指导、教材的编写和师资队伍的建设等都是亟待解决的主要问题。而这篇短文则对美国教育界积累了将近一个世纪的工业工程专业办学经验进行了深入分析并就21世纪工业工程教学体系的建设予以了展望。相信文中的观点能够对正处于启蒙阶段的我国工业工程教育体系的建立起到指导和借鉴作用。

2 Real IE Value
工业工程的真正价值

Industrial engineers are great at solving problems. Ironically enough, there is still one age-old problem they are unable to solve — identity. And the problem is not getting any easier to solve. In fact, "identity" is just one of several challenges currently facing the IE profession.

Today's competitive global economy and tighter corporate budgets are forcing IEs to deal with issues that were barely mentioned a decade ago. Companies are flattening corporate structures; IE departments are being eliminated or renamed; and universities and colleges are under even greater pressure to provide industry with graduates who are better trained to handle a much wider variety of job responsibilities.

On the other hand, today's IE has at his or her disposal more technology and tools than the IE of 30 years ago could have ever imagined. New technologies have improved accuracy and speed and generally have increased the IEs' ability to cover a more diverse set of interests.

In addition, the IE now has a greater opportunity to concentrate on any one of a broad variety of areas that many companies now recognize as individual departments — including simulation, operations research, ergonomics, material handling and logistics.

The name game

What problems could possibly throw a shadow on such a bright array of opportunities? For starters, as new opportunities have developed for the IE, new questions have formed about what types of jobs the industrial engineer is qualified to perform.

At one time, it was easier to define what an IE did. "Industrial engineering was simple in those days when we dealt with methods, work standards and work simplification," says Carlos Cherubin, director of engineering for The Limited Co. "But there has to be some way to get past the old industrial engineering definition."

Even today, in many companies, IEs are still performing the traditional type of work that makes up what is now considered classical IE. "The big change is that the commercialization of a lot of these areas has turned them into 'niche thrusts,'" says John Powers, director of the management services department at Eastman Kodak Co. While IEs have always been very adaptable to these "thrusts" as a skill set, he says, they are now competing for the headlines.

Says Jerry Zollenberg, director of IE for United Parcel Service, "If a person loses sight of the total job and starts looking at the individual pieces, it comes out a little hairy." For example, Zollenberg says that he has an operations research (OR) group of 40 to 50 individuals who are working on the cutting edge of computer technology. At one time these people were designated as IEs. But Zollenberg says that even though they are not called IEs, the job they are doing is certainly IE-oriented and could be IE, depending on how you set up the organization.

Like it or not, the trend today is specialization, and companies are following suit. Tough economic times are forcing many companies to redefine corporate structures, with a primary goal of flattening their organization in an attempt to cut costs and speed the decision-making process. In the case of the IE department, that trend has moved departmental names from the generic "IE" to specific functions or areas that are being performed. Former IE departments have been decentralized or renamed and are now described using such terms as Quality Improvement Engineering, Management Services or Engineering Services, just to name a few.

"What I see is companies getting away from the IE name and trying to have names that are more descriptive of the broader set of skills," says Powers.

For many, including Rebecca Ray, IE manager at Glaxo Inc., it is a step in the right direction. Her department will soon carry the title Performance Improvement Engineering. "IE is probably the only engineering profession that insists on wearing its degree on its departmental door," she says. "We have focused too much on maintaining our degree, instead of identifying our function within our company."

Dr. Vinod Sahney, corporate vice president at Henry Ford Health Systems agrees. "One of our biggest difficulties is we equate industrial engineering with an IE department," he says, "I have never seen a mechanical engineering department, but yet they are hired and get a wide-range of jobs."

Tony Vieth, IE manager at Boeing Georgia Inc., believes that the individual persons, depending on how they are trained, can bring the right skills to the right job and they do not need to be in a department called industrial engineering. He also thinks IEs have gotten hung up on that over the years. On the other hand, the decentralized type of environment appears more threatening to others. "If we assume that decentralization will continue to the point of transferring IE responsibilities to others, as seen in the Volvo organization, we will see a profound impact upon the profession, namely unemployment," predicts Donald Barnes of Barnes Management Training Services.

But, a centralized IE department does not guarantee employment for the industrial engineer. Many large companies have "IE" departments where only a handful of industrial engineers can be found. An example is Boeing. Boeing has some very large IE departments, but often less than two or three people within the department have IE degrees. According to Vieth, it is because some of the functions within the department are so diverse.

Problems associated with renaming IE departments to describe their particular function may have more to do with appearance than with the actual job being performed. While IEs actually perform many of the specialized jobs, little credit is given to IE principles used in the approach. In fact, it often turns out that many of the individual functions and skills used by IEs are viewed by management as industrial engineering. As a result, individuals who can master one of those skills are mistakenly referred to by management as "industrial engineers."

Yet, those who understand the real value of industrial engineering still realize that the degreed IE brings to the job a unique way of thinking.

"There are things you can teach non-degreed people that are basic repetitive tasks," says Vieth. "But what you can't teach is how to take what you see, translate it, and recognize there is a problem, and then come up with a solution to that problem."

Erin Wallace, director of IE at Walt Disney World Co., would not hire anyone who was not a degreed IE. "I insist on it," she says. "When you've got a group of people who are distinctly IEs, they carry with them what we like to refer to as distinct competencies. Those distinct competencies for an IE at Walt Disney World include their ability to do quantitative analysis. You need an IE degree to be able to do that type of work."

Wallace says that when someone hires IE technology-type majors, they do not get some of the rudimentary problem solving skills acquired from taking engineering courses.

Curriculum

Since there is a favorable consensus about the technical qualifications of degreed IEs, universities and colleges must be doing all industry believes necessary to prepare today's IE students. Appearances may be deceiving.

In fact, even though ABET accredits many IE and IET programs in the United States, there remains much variance and flexibility among each of the programs. Evidence of this fact can be found in a recent Australian study undertaken by the Industrial Engineering/Management (IE/M) group of the School of Mechanical and Manufacturing Engineering Swinburne Institute of Technology (SIT).