J. Webster (ed.), *Wiley Encyclopedia of Electrical and Electronics Engineering*

PROFESSIONAL PREPARATION

Today's engineer is in the most exciting arena of life. Engineering is challenging, rewarding, and limited only by one's ingenuity. It is a creative profession which continues innovation with the materials and forces of nature. It extends the fundamentals of science to useable products and processes for society's benefit.

Most people were skeptical in May 1961 when President John F. Kennedy announced that the United States would go to the moon and return before 1970. But skepticism disappeared when it was accomplished in July 1969. Jules Verne (1828–1905) conceptualized a journey to the moon in 1873 in his *From the Earth to the Moon*—and he wasn't even a scientist or engineer. He was a French science fiction writer, the forerunner of modern science fiction writers, who had ideas ahead of his time but couched them in the basics of science. Present-day engineers with vivid imaginations overshadow the accomplishments of the past.

The connotation of "professional preparation" suggests logical methodology. That notion is real. What, then, may one do to prepare for this innovative profession? The discussion centers on undergraduate education, graduate study, and engineering practice (career development). The reader will hopefully recognize that there are many overlapping areas, such as professionalism and ethics, which are both "taught" and "caught."

Baccalaureate Degree

The quickest way for employment in a profession is by earning a baccalaureate degree in one's discipline of choice. It is becoming more important to also pursue graduate degrees in order to better cope with current technological developments.

Accreditation. The baccalaureate degree which is earned should be in a program accredited by the Accreditation Board for Engineering and Technology (*ABET*), the national engineering accreditation agency. The Engineering Accreditation Commission of ABET prescribes the minimum requirements for basic- or advanced-level accreditation (1). The programs pertinent to this treatise include *electrical engineering, electronics engineering,* and other engineering programs with similar modifiers in their titles. For simplification, we shall hereafter refer to all such programs as *electrical engineering.*

The basic ideas behind accreditation of engineering programs are: (a) *quality control*—that any student who graduates from an ABET-accredited program meets defined minimum requirements; and (b) *truth in packaging*—employers and graduate schools know the backgrounds of their personnel.

It goes without saying that the curriculum must include the technical fundamentals of electrical engineering. Every electrical engineering professional must be intimately familiar with Ohm's law, Kirchhoff's laws, and how electrons flow in both direct and alternating current, for example. They must have a working knowledge of systems and components, circuits and terminal devices, and controls and measurements. They must understand electromagnetic fields and wave phenomena. They must be able to mathematically model physical phenomena and to measure pertinent electrical quantities.

Equally important are the other components of the curriculum that tie together the technical elements. It is highly probable that these other components will determine the ultimate success of the electrical

Table 1. Evolving Engineering Criteria

	≤1962	1963±1995	≥1996	≥2000
Mathematics	½ year	1 year	1 year	1 year
Basic sciences	½			
Engineering sciences	1	1	1½[a]	1½[a]
Engineering design	½	½		
General education (~technical component)	–	–	–	½
Humanities and social sciences	½	½	½	–
ABET specified	3 years	3 years	3 years	3 years
Other (institution specified)	1	1	1	1
	4 years	4 years	4 years	4 years
		Optional 1992–95		

[a] Engineering topics = Engineering sciences + Engineering design; ½ year = 16 semester (24 quarter) hours.

engineering practitioner. The other components include, but are not limited to, basic education, social sciences, communication skills (verbal and written), interpersonal relationships, and ethics and teaming.

Curriculum. The accredited basic degree must include the components shown in Table 1. It summarizes the progression history of the engineering curriculum from the beginning of ABET [formerly called Engineers' Council for Professional Development (*ECPD*)] accreditation in 1934. Definitions of the components and details of the curriculum are included in the integral article entitled Curricula.

Interpersonal Skills. Student interactions with other students and with their mentors set the tenor for practitioner interactions. We learn in school how to behave in life. Since most behavior is learned, it is important that engineering students progress through interfacing on laboratory teams, working together on special projects, and interacting with their teachers. They may also learn from other professionals who may be invited to participate in the educational programs via guest lectures, development programs, and research projects.

Teaming. One of the most educational aspects of the formal engineering education program is participating as a team member in laboratory projects. Providing critical data on one's individual part of the project may make or break the entire project, just as in real life. Being on time with the data is crucial. Taking into account other team members' contributions is a necessity. Continuing inquiries with other team members keeps the project on schedule and endears the individual to others. Cooperation is the key word. These are characteristics of behavior which may be learned and honed to perfection by interacting with others under the direction of a professional mentor. Teaming becomes more important as the student approaches graduation, notably in senior-level capstone design projects.

Nothing develops the undergraduate's ability to interface with others more than regional and national competitive events where teams of students vie for the best robot or the most accurate control system. Examples include the IEEE's southeast Education Conference's annual competition and the national/international solar-energy-powered vehicle races. These competitive academic models are extended into professional practice via conferences, competitive paper events, and multilevel grades of membership in professional and technical organizations on a personal basis.

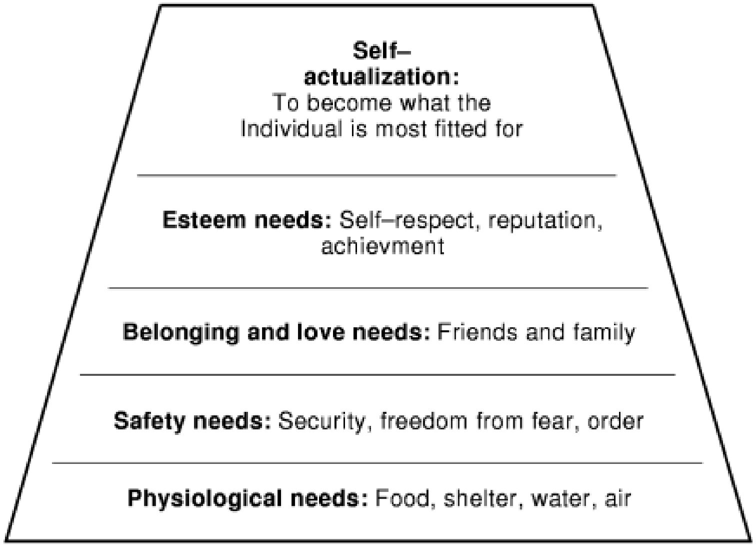

Fig. 1. Hierarchy of needs. From lower-level basics of life to upper-level individualized ambitions. Higher-level needs become important when lower-level needs are satisfied.

Communication Skills. Nothing defines professionals' progress as much as their ability to communicate, both verbally and in writing. An excellent idea may be lost if left noncommunicated to colleagues. An innovative product may languish in the laboratory if venture capitalists cannot be sold on its merits. A contract may be lost to a competitor who drafts a better proposal or even a letter of first contact. Good ideas must be conveyed to others in order to enjoy success in our society.

In school, speech courses encourage us to practice our presentations before a mirror. Better yet, the videotape recorder provides an ideal way for us "to see ourselves." We would not attend a play where the actors did not rehearse in order to hone their performances. Why should we expect fellow students or practicing professionals to be more receptive to our presentations? We should recognize both the impact and the limitations of audio–visual aids. We live in an era of the 45 s film clip. For the most effective presentation, we must adhere to the attract-and-hold-attention concepts that are extant today. For example, a slide should not normally be left before an audience for more than a minute. And it should only be used when pertinent to the comments being made and when germane to the central subject.

Personal Esteem. Perhaps just as important as the message that is conveyed through communication is the building of personal esteem. A well-done paper or presentation gives the author or presenter a satisfying feeling, develops confidence, and makes the next project easier. Personal esteem includes self-respect, achievement, and recognition. Attracting and maintaining the respect of peers is crucial to professional success.

Self-esteem is critical to becoming a successful practitioner. It centers on personal worth and completeness. It affects the individual's ability to produce results. Success breeds success.

Motivation. Maslow (2) defined a hierarchy of needs, shown in Fig. 1, which relate to motivation. Since needs must be satisfied from the bottom up, with the most fundamental needs forming a broad base of support for further development, it is easy to see that higher-level needs become important when lower-level needs are satisfied. As one works toward the upper level, ambitions and abilities are realized. It is the need to be the best that drives the ultimate professional.

Internship. Recognized for centuries as being one of the most important ways to develop professionally, internship has been somewhat neglected at the undergraduate level in engineering education. Formal *cooperative education* programs constitute the most common internship program in engineering education. They consist of alternate work and study programs, ranging from seven weeks to one year, usually quarter-by-quarter or semester-by-semester. As an added benefit, the participant learns and earns simultaneously. Ideally, either formal or informal study are continued while the individual is on a Co-Op industrial or governmental assignment.

Very few institutions now require engineering students to participate in a Co-Op program. While everyone recognizes the benefits of professional interactions at key junctures within the educational process, both students and faculty members usually want the students to progress as rapidly as possible to graduation. The argument is a financial one since delayed graduation is rarely compensated by higher earnings of the graduate who participated in the Co-Op program. Participation in a Co-Op program should not be based on finances but on motivation. It is also worth mentioning that Co-Op students are highly sought in the employment market.

Co-Op students who have been on an industrial assignment always come back to school with a fresh outlook. In isolated cases while on assignment, some students may decide that engineering is not the career for them. In a majority of cases, however, returning students are motivated to excel in their engineering classrooms and laboratories. They are often motivated to accelerate their graduation. In many instances, Co-Op assignments provide laboratory projects; and, in some cases, returning students are permitted to work on company-sponsored projects which provide modest stipends for the students while in school.

Ethics. Ethics deals with what is right versus what is wrong. Engineering ethics is simply the adherence to prescribed rules of conduct which pervade all society while in school and in practice. Ethics is obviously not limited to engineering. Inculcating good ethical behavior begins with the family, extends through engineering education, and continues throughout the life of the practitioner.

Cheating and *plagiarism* are the first elements of ethics encountered in school. There is sometimes a fine line between working together in order to learn more in the academy, or to produce more in the workplace, and in submitting one's own work for recognition and credit. Clearly, the best way to learn is by studying or working with someone more intelligent or more innovative than ourselves. The approach to problem solving and to creative concepts "rub off" from others. Getting an answer to a question at the time it arises is the most efficient learning mode. Sometimes a word or two from a colleague (student or practitioner) or mentor (teacher or supervisor) can be more beneficial than a week of self-study.

Whether in school or the workplace, credit must be given where it is due. As young children, we learn that we should not take credit for the work of someone else. That principle extends to adulthood in the academy and in the workplace. We don't "copy" someone else's work for credit on an exam or for recognition in a treatise submitted under our name. We don't forge another person's name on a check. We don't alter grades in the teacher's grade book or hack the university computer to alter records. These are examples of violating ethical behavior.

As an example of ethics, consider the case of an undergraduate who gained access to a university's computerized records to get names and addresses of students who belonged to a certain religious organization—in the days when such data could be a part of official records. He wanted the names and addresses in order to invite the students to participate in functions affiliated with their religious body. But he gained access to them by unethical means. His motives were pure, but his actions were not. This illustrates the fine line that is often faced by both students and practitioners.

Some people falsify their own records, pad their resumes, and exaggerate credentials in an effort to further their careers. In the science and technology spectrum, one of the most common cases is that of graduates of engineering technology programs or engineering-related programs claiming that they are engineers. In some instances, their alma maters may even be guilty of promulgating this impropriety by publications which are inexact or omit key descriptive material.

Perhaps the most widely prevalent breach of ethics in engineering—and probably other professions—is the copying of computer software. Unless in the public domain, a computer program is the work of its author—

just as much as a book. Both are intellectual property, analogous to real property that should not be stolen. Moral dishonesty is a violation of ethics.

Professionalism

A *profession*—such as medicine, law, ministry, engineering, architecture, and teaching—is generally defined as a vocation which has the following common characteristics.

- Specialized knowledge
- Education and/or training required
- Standards promulgated by force of organization or concerted opinion
- Code of ethics
- Responsibilities to the public exceed those of clients
- Public recognition
- Police, reward, and punish practitioners

Professionalism embraces the adherence to these characteristics while engaging in practice. Engineering qualifies as a profession in all of these.

A *professional engineer* is one who practices while adhering to these characteristics. Attaining specialized knowledge is a multifaceted process. The beginning path in obtaining specialized knowledge is that defined above—that is, beginning with an ABET-accredited baccalaureate degree in engineering. After graduation, the path may differ, depending upon individual goals. About one-third of today's graduates opt to continue their education into graduate school. (See the section entitled "Graduate Study.") Some go through formal industrial indoctrination programs, including specialized education and/or training.

Professional Registration. A graduate engineer cannot legally practice in fields which involve the safety and welfare of our citizenry without being professionally registered. Currently, all of the states in the United States require that a professional engineer, entitled to bear P.E. after his/her name, go through a registration process prescribed by the laws of the individual states, most of which comply with the "Model Law" promulgated by the National Council of Examiners for Engineering and Surveying (*NCEES*). Most states require:

(1) Graduation from an ABET-accredited engineering program.
(2) Passing an eight-hour, limited-reference Fundamentals of Engineering (*FE*) examination near the end of the degree program or after graduation, covering the subjects of mathematics, physics, chemistry, and basic engineering courses. [Some states call their exams Engineer-in-Training (*EIT*) or Intern Engineer (*IE*).] The only reference that may be used on the exam is the NCEES' *Fundamentals of Engineering Reference Handbook*.
(3) Practicing in a responsible engineering position under the direction of a registered P.E. for a period of four years following the baccalaureate degree.
(4) Passing an eight-hour, open-book Professional Engineering (PE) examination, which covers only subjects from ones area of specialty. [In some states, the examine is called Principles and Practices, *P&P*.]
(5) Satisfying the cognizant state Registration Board that the candidate's character is acceptable. This involves references and usually a personal interview by the Board.

The FE and PE examinations are offered simultaneously in all states. The morning session of the FE examination covers the subjects of

Chemistry
Engineering economy
Fluid mechanics
Mathematics
Statics

Dynamics
Electrical circuits
Material science and structure of matter
Mechanics of materials
Thermodynamics

The afternoon session covers the subjects of

(1) Applied mathematics
(2) Electrical circuits
(3) Thermodynamics and fluid mechanics

(1) Engineering mechanics

Engineering economy Engineering mechanics includes statics, kinetics, kinematics, and mechanics of materials.

Individual state Registration Boards purchase the tests from NCEES. The Boards are responsible for distributing the applications for the exams, administering them, grading them, and notifying the examinees of the results. The Boards also establish the passing cutoff scores, causing some critics to charge that the exams are not uniform, since the boards in neighboring states may not choose identical cutoff scores.

Minor deviations in the path to professional registration is permitted by some Registration Boards. For example, 50% of a student's time spent in graduate school is usually credited toward practicing under a registered P.E. After an individual is registered in one state, most other states accept his/her credentials, via *reciprocity* or *comity,* for parallel registration in their states. The fundamental premise of the registration process is to protect the public by preventing unqualified people from offering engineering services.

Engineers who work for companies that design and manufacture products are exempt from the licensing process—known as the industrial exemption. Unfortunately, the industrial exemption has kept some engineers from becoming registered P.E.s. In the view of many, it has also held back the development of professionalism while keeping the number of registered professionals at a low percentage. That this view is correct is evidenced by the necessity of successful examinees to meet minimal pass requirements. While this does not mean that an individual who fails the exam is deficient in his/her education, it does mean that he/she is deficient in that aspect of the education. Despite the arguments for the industrial exemption, most people agree that being a registered professional engineer is an important step in the development of professionalism. It is, of course, not the only step.

Graduate Study

One may pursue a graduate degree after obtaining a baccalaureate degree—such as masters and/or doctorates within engineering or master of business administration outside of engineering. Some graduates pursue other professional degrees, such as medicine and law. Most professional schools outside of engineering see an undergraduate engineering degree to be excellent preparation for their post-baccalaureate programs.

Most graduate degrees that are obtained by students with electrical engineering baccalaureate degrees are within their discipline of electrical engineering. They involve such subspecialties as

(2) Antennas
Circuits
Computers
Digital systems
Power
Electronics
Lasers

Plasmas
Signal processing
Telecommunications
Microwaves
Networks
Instrumentation
Microprocessors

Some engineering graduates pursue advanced degrees without getting a baccalaureate degree. This is especially true when an advanced degree is considered to be the first professional degree. For example, an institution might offer a master of science degree in biomedical engineering, which requires courses in medicine and electrical engineering. But an engineering baccalaureate degree is required for all engineering graduate programs.

Advanced-level criteria promulgated by ABET (1) provide (a) additional depth in the primary engineering discipline, (b) additional breadth in engineering areas related to the primary discipline, (c) deeper immersion in cultural, social, and/or business studies related to engineering practice, (d) emphasis in the broad study of manufacturing, construction, engineering management, and/or engineering entrepreneurship, and (e) programs that are offered jointly by the engineering unit and another academic unit. Very few graduate engineering programs are ABET-accredited because funding bodies, particularly federal agencies, reward the depth of “research” rather than the breadth of “practice.”

Graduate study in ones own discipline permits him/her to develop depth, integrate peripheral fields of study, and become an authority in a specialized area. Graduate degrees may be *research-oriented* or *design-oriented.* The largest percentage of advanced degree programs are currently research-oriented because support for the academic work is provided through research grants/contracts. Research projects then become the vehicle for the students’ specialized area, their areas of depth. Research-oriented advanced degrees are normally entitled Master of Science, Master of Science in Electrical Engineering, Doctor of Philosophy, and Doctor of Science.

Design-oriented graduate programs are often based on industrial-sponsored projects, sometimes centered on a product and/or process development and/or refinement. Such projects often have a shorter time frame since industry has to provide quarterly reports to the stockholders. They are frequently more consumer-oriented. Degrees granted are normally called Master of Engineering, Master of Electrical Engineering, and Doctor of Engineering. It is not possible to say whether the research- or design-oriented program is better. The answer is dependent upon the sponsoring agency, the academic institution, the graduate-study mentor(s), and the individual student—with all of them centered on the goals of the program. Currently, the research-oriented programs more nearly meet governmental agenda, while design-oriented programs more nearly meet industrial agenda. The confusion grew out of the early pattern of science funding from the federal government by agencies such as the National Science Foundation, which is largely based in science rather than engineering.

Graduate programs normally require a research thesis/dissertation or a design report. Abridged research theses are generally published in international journals and presented at national forums. But the publication outlet for design reports is often limited to specific industries. Or the design report may not be published if it involves a company-proprietary project. The results of a design report may simply be locked up and kept from the world if deemed proprietary by the industrial sponsor. This restriction keeps the percentage of design-oriented programs low.

Career Development

The disciplines of engineering (chemical, civil, electrical, industrial, mechanical, etc.) generally relate to the interest of an engineer. The functions of engineering—which are used as the subtitles of this section (research, development, design, production, etc.)—relate more closely with aptitudes, training, and career assignments of the individual practitioner.

Functions of engineering characterize the type of work an engineer does after graduation (3,4,5,6). For example, one may be intimately involved in the design and development of a product which straddles disciplines, say electrical and mechanical engineering. Career development generally parallels the functions of engineering—within, but most often across, engineering disciplines.

Practicing engineers are called upon to do so many things that do not fall within their disciplines. The degree of specialization is defined by the job assignment. For example, research in microelectronics is obviously more specialized than the management of a manufacturing plant. The former requires intimate attention to details and technological nuances. The latter demands a breadth of expertise, including interfacing with a myriad of people and functioning with budget constraints.

Most modern-day products and processes involve the discipline of electrical engineering, as a minimum in measurement and control. But it is most often impossible to bring a product or process to fruition without straddling disciples. One only needs to be out of engineering school a short time to realize that real-world problems are not naturally compartmentalized by engineering discipline.

It is imperative that career development follow the functions of engineering if the practitioners are to advance in their professional careers. Professional preparation does not end with graduation. It is an ongoing process which normally leads to advancement in one's career. Without it, the half-life of an electrical engineer is less than five years.

Creativity and innovation are central to the more esoteric aspects of engineering. But what are they? *Creativity* is artistic or intellectual inventiveness which arises from imagination. Children often conjure up entire armies or invaders from outer space with cardboard boxes and blocks—that is, until adults sever that imagination by forcing them into their molds. Creativity is a very personal and individual thing. It is the spark, the light bulb, the new idea. It strikes at uncommon places and at uncommon times—for example, when one is sitting in church or sleeping.

Innovation is a new concept—method, custom, device, process, or product. It is a change in the way of doing things. It is the entire scenario from creating a new idea through development, production, and use of the product or process. Creativity is usually required in the early stages of this scenario, and often new sparks occur along the way when creative people are involved. But ideas are not enough; they must be good ideas. Benjamin Disraeli said about a colleague, “He had only one idea, and that was wrong.” We do not think in a vacuum. Even the most abstract ideas are influenced by one’s environment.

Research. A pundit has characterized research as “looking in a dark room for a black cat which is probably not there.” Research demands detail; concentration on current technological developments; and being able to extrapolate beyond current products, processes, analytical techniques, and common approaches. The researcher must be well grounded in the basic sciences and mathematics.

Research is often perceived as the glamorous function in engineering since the practitioner is always “on the edge, pushing on the boundaries.” Most researchers enter their positions after obtaining a graduate degree, or degrees, which prepare them for specialization. They often delve into the nature of matter and investigate the behavior of materials when subjected to a variety of forces and environments. Their work frequently overlaps with that of scientists. Stated another way, their function is close to the science end of the technological spectrum.

An engineer conducting research is expected to be acquainted with the most advanced analytical tools—mathematical techniques and computer codes, for example. The objective of research is to discover truths and find a practical use for them. Oftentimes there are surprises, such as the unexpected making of nylon, super-glue, and a variety of other products which “popped up” while the researcher was working on other matters.

Research engineers, more than in any other function, must remain abreast with the developments in their areas. That requires reading (a) the current research journals, (b) key dissertations and theses produced in graduate schools, (c) papers presented in national and international meetings, and (d) specialized monographs. It requires attending forums, workshops, seminars, and short courses within the research area. Contact with key colleagues, within one’s own organization and without, is imperative.

Except in proprietary cases, it is usually to the practitioner’s advantage to share expertise with colleagues, taking advantage of synergism. Reviewing papers prior to publication and proposals before awarding helps keep one up-to-date. Innovations may need to be patented, which requires extra detailed efforts but which are worthwhile in building a personal resume and in furthering one’s organization’s interest.

To stay at the forefront, it is often necessary for a research engineer to take graduate courses which have developed since getting his/her degree(s). Such specialized courses are often offered at a time and place convenient to the practitioner since graduate schools and employers cooperate in the interest of both parties. Employers often pay for such specialized education, but the serious practitioner will not let reimbursement policies stand in the way of getting the needed updating.

Professional preparation for research includes developing patience and learning to cope with failure since much of the work involves trial and error and painstaking details. The researcher must be very perceptive, latching onto details that have previously been ignored or unseen. Oftentimes, the final result is far different from that envisioned from the outset.

Development. The development engineer takes the natural phenomena and concepts discovered or formulated by the researcher and “develops” processes and devices that utilize those phenomena and concepts. Development often overlaps with research so much so that it is common to see Research and Development (*R & D*) departments.

Engineering development involves the generation of models that may be used in pilot processes or techniques. Innovation and creativity are central to the attributes needed by the development engineer. Development engineers meld a clear understanding of the fundaments of basic science and cleverness in making things work. They are ideally tinkerers who enjoys “bread-boarding things together.”

Development engineers' efforts involves layout, building, and testing of the experimental models which will lead to the ultimate product or process. They are always interested in producing a process or product that will function commercially. The product or process must work, be economically feasible, and meet specified objectives.

While the researcher deals most often with unknown factors, the development engineer frequently uses existing products and processes to perform new and different functions. The interlinking of products and processes is important in development. Patents are more common in development than in research.

In professional preparation, the development engineer must amass a mental library of techniques, processes, mechanisms, and components whose functions are well known. They must be such that they can be brought together into a new functional relationship. A control circuit may trigger a laser in intergalactic mapping as easily as it switches on a water pump in a fossil fuel power plant. Knowing the capabilities and limitations of the library of elementary units is, therefore, an absolute necessity if they are to benefit the development engineers in their quests for a "better mousetrap."

Since we never want to "reinvent the wheel," searching the literature for the right component in a new device is one of the steps in development. The practitioner must then be aware of the key journals and monographs which might provide clues to the new product or process. Manufacturers' literature is also a major source of information to meet the objective(s). Nowadays, many data are available on the Internet or World Wide Web, which must be readily accessible to the development engineer.

A systematic search of the literature may reveal existing units which may be integrated to meet the objective without substantial modification. Ideally, the integration should be done with cognizance of the economic benefits. The savvy developer is discriminating in drawing a line between modifying existing products and starting over. Sometimes mathematical analyses or computer models will facilitate making a decision in the development process.

After dividing the anticipated new device or process into several integrated segments, the development engineer may then piece together a variety of solutions to reach the desired result. Modifications may be made in an individual segment without interfering with the other segments. When the system is in a workable state by engineers who understand its intricacy, it may be refined to be operable by less knowledgeable people in a safe manner. Development engineers often begin professional practice after getting an advanced degree(s). Their professional preparation closely parallels that of the research engineer. In many respects, the developer stands between the researcher and the design engineer but overlaps with both.

Design. The definition of engineering design by the Engineering Accreditation Commission of ABET is an appropriate introduction to this engineering function (1):

> Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include at least some of the following features: development of student creativity, use of open-ended problems, development and use of design methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, and detailed system descriptions. Further, it is necessary to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact.

In general, design is characterized by efficiently bringing together components and current technology to result in a device or process which will benefit society. It normally entails using up-to-date analytical techniques, materials, and manufacturing processes. Form and function are often equally important.

The design engineer bridges the gap between the laboratory and the production process or construction. Design engineers probably need an even greater repertoire of procedures, processes, mechanisms, components, and subsystems than do development engineers. Their professional preparation necessitates cataloguing such entities so that they may be readily brought to bear on the solution of a new configuration or objective.

In the most general sense, design engineers take the “bread-board innovation” from the developer and give form and function to it. They devise the shape, strength, and operational configuration of the machine or process, specifying dimensions, materials, and the intricacies necessary for manufacturing or construction. The design engineer must anticipate misuses of the product, failure mechanisms, and maintenance requirements.

Professional preparation to become a design engineer requires the following: solid grounding in mathematics and basic sciences; an understanding of machine capabilities; the ability to “see” things that have never existed; an understanding of various materials; an appreciation of the environment; knowledge of codes and standards; application of safety principles within our litigious society; and familiarity with manufacturing and construction techniques. Most of these requirements necessitate (a) continued learning via reading design magazines, manuals, and trade journals, (b) keeping track of changing codes and regulations, (c) being sensitive to costs of producing a device or structure and for the maintenance of them, (d) knowing life cycles, and (e) environmental changes.

One of the important attributes of a designer—the ability to see things that have never existed—appears to depend upon an innate ability, which must exist before being enhanced by education and training. Some people just visualize things better than others. The most esoteric researcher frequently has trouble seeing an innovative application. Engineers sometimes have trouble visualizing the flow of electrons without likening it to the flow of a fluid.

In the arena of mass production, the cost per piece is very important, often making or breaking a product whose cost is within two mils of another one. Style, appearance, and expected life of the product are very important. A consumer product must appeal to a customer in order to be marketable and in order to survive the competition.

In construction, the resulting design is for one building, bridge, or control system. While total cost is still an important factor, maintenance becomes even more important. The replacement cost and component life cycle are, therefore, crucial to the long-term acceptance of a design.

Another design parameter, which is not yet spelled out in the ABET criteria for accreditation but which is becoming increasingly important, is *disposability,* or *recycling.* Its importance is very paramount where health factors are involved. There are some rational reasons for recycling: to reduce pollution (water and air), to save landfill space, to cut down depletion of natural resources, and to reduce cost. The benefits are both environmental and economic. Clearly, recycling requires judicious design of the products being manufactured so they will be inexpensive to recycle. In general, if a product is not biodegradable, it should be recyclable.

The safety design parameter merits special attention in our litigious society. The basic tenet in engineering is that a danger must be “designed out” of machines, processes, and structures wherever possible. If the danger cannot be eliminated by design, such as at the point of operation in a machine, we must guard the danger region. If unable to totally guard, then we must warn users by signs and instructions. For example, a table saw will not function if the blade is totally inaccessible. The blade, therefore, must be guarded, but the material must come in contact with the blade in order to be cut, requiring exposure to the danger element. Warnings are then placed on the unit about the danger and its consequences.

In engineering, we must always design systems that will “fail safe.” For example, if a tractor-trailer loses its air pressure on the highway, the trailer brakes automatically lock. Engineers design interlocks to prevent inadvertent injury. For example, a clothes dryer quits rotating when the door is opened. If an elevator cable snaps, letting the elevator begin to fall freely, a set of brakes grabs the ways in which the elevator runs, thereby stopping it quickly and gently. Automobiles have redundancy built into their brakes and accelerator linkage systems. These design schemes are a part of the engineer’s repertoire to prevent death, injury, and destruction of property. In devising a fail-safe system, the design engineer must always keep in mind that only gravity can be depended upon in the event of a failure.

Codes and standards play a major role in protecting our citizenry. No pressure vessel can be sold in the United States, and many foreign countries, without having the American Society of Mechanical Engineer's (*ASME*) code stamped on it, signifying that it complies with rigorous safety standards. Water heaters must be equipped with code-approved pressure relief valves. Portable electric heaters must be equipped with switches which deactivate them if they are overturned. Lawn mowers are equipped with kill switches to reduce their propensity to cause injury. Electrical design engineers must be at the forefront in seeing that machines and structures are equipped with interlocks which prevent injury to users of them.

As an important part of professional preparation, the design engineer must remain abreast of the pertinent regulations and standards, which are promulgated by hundreds of agencies and organizations. Regulations are requirements by governmental agencies. Examples include: (1) the Federal Motor Vehicle Safety Standards (FMVSS) issued by the US Department of Transportation and (2) Occupational Safety and Health Administration (OSHA) regulations by the US Department of Labor.

Voluntary standards, promulgated and/or coordinated by the American National Standards Institute (*ANSI*), call for that which should be done by a prudent manufacturer or builder, and less frequently by the employer or user. Oftentimes, standards are adopted by governmental agencies, which gives them the force of law, making them regulations. For example, pertinent sections of the *National Electrical Code,* by the National Fire Protection Association (*NFPA*), have been adopted by all states to govern the safe installation of electrical wiring and components within building. The *National Electrical Safety Code* (ANSI C2), promulgated by The Institute of Electrical and Electronics Engineers (*IEEE*), governs transmission lines and associated equipment (outside of buildings) throughout the United States.

Multiple designs exist for any objective. Optimization then becomes important to the design engineer. The optimization process must include not only quantifiable factors—such as current, voltage, and cost—but form factors—such as shape, color, and appeal. Evaluation methods are continually being upgraded to account for all of the factors of optimization. The up-to-date design engineer must remain current in these matters via participation in seminars and other specialized forums. Judgment eventually determines the final design. And judgment is the sum of one's total experiences.

Design engineers must be more attuned to people problems than either the research engineer or the development engineer. They must interface with those who manufacture the products or build the structure. And those who manufacture and build never hesitate to tell the designer all of the reasons why a thing cannot be done. The design engineers must then be persuasive, being well acquainted with their arguments before trying to "foist them on the old pros."

Since every design involves a departure from that which has been done before, it is imperative that the design engineer be creative and innovative.

Production (Manufacturing). The conversion of raw materials into finished products is the objective of the production engineer. Cost of production is usually paramount. It is dependent upon the manufacturing process and the cost and flow of raw materials.

The production engineer should interface directly with the design engineer while products are being designed, making suggestions for ease of production—selection of materials, processes and procedures. Such collaborative efforts are sometimes referred to as *concurrent engineering* and take advantage of total quality management principles. Frequently a small change in design will significantly facilitate manufacturing and assembly, thereby reducing cost. For example, loosening a tolerance from 0.01 mm to 0.03 mm may reduce production costs by 20%.

Production connotes manufacturing, which may be quite varied depending upon the materials being used and the processes selected. For example, the manufacturing of plastics components is significantly different from making parts of metals. A plastic blow molding operation has very little similarity to a sand casting operation. The production engineer must be thoroughly acquainted with the capabilities and limitations of the machines which are utilized in manufacturing.

Electrical engineers are often needed in planning for energy requirements in manufacturing, which may involve short-term bursts of power. Cycling and timing are generally intimate to processing. The emphasis of the production engineer is on *how to* manufacture the product after the design engineer has defined *what to* produce.

The technical aspects of manufacturing include: flow of the product; distribution of energy (electric, gas, hydraulic, pneumatic); forming of components; specialized treatment of components; timing of subassemblies in the flow; in-line testing of components and subassemblies; inspection and rework; packaging; and shipping. The production engineer is responsible for selecting tools and processes to be used in the manufacturing process.

The production team consists of engineers, technicians, craftsmen and assembly line workers. Their expertise ranges from highly specialized to very limited, requiring the production engineer to have a special knack for placing team members in the best niche for optimized results.

The more difficult part of manufacturing may be scheduling and staffing. Startup and shutdown of assembly lines become important in shift scheduling. The most difficult of all is the relationship with people, but it may be the most rewarding. Assembly lines are so often staffed by lower paid workers that training become a very crucial aspect of manufacturing. Training is normally a joint responsibility of the production engineer and the manager of human resources.

Many of the problems associated with production are not covered in engineering schools. Most manufacturing operations are not organized under engineering but rather under management, which requires the production engineer to interface with sometimes competing forces. Professional preparation must, therefore, include attending specialized seminars and in some instances proprietary workshops conducted by the providers of assembly line equipment. Specialized training in production processes, economic analysis, and quality control is often a necessity.

Ideally, the production engineer should work closely with the sales staff. This is especially important since the production engineer operates under constant pressure and deals with machines that are often pushed to the limits of their capability. Sales wants more output; maintenance wants more time; some materials are not available and substitutes are necessary; and the design engineer may want to make a last-minute change in the product. Life is not easy for the production engineer!

In every decision, the production engineer must make the product for the lowest possible cost. This necessitates professional preparation with a strong background in engineering design, economics, business, and psychology—some of which must come through continuing education and professional development activities.

Construction. The primary difference between production and construction is in the quantity of the end product. The production engineer may turn out millions of components per month, whereas the construction engineer may spend many months on a single product. As used here, the term *construction engineering* means the work of building structures that have been designed previously and will be operated subsequently. The structure may be a building, a dam, a bridge, or an elaborate control system for a nuclear power plant.

Scheduling of tasks and utilization of people are key aspects of construction. In most projects, the construction engineers will have been associated with the bidding on the contract—time requirement and people needed—making them cognizant of detailed costs. The flow of construction materials is very important since every delivery may put them in the way, and late delivery may require layoffs of people and missed target dates.

The construction engineer must be able to relate to construction craftsmen, deal with labor unions, and interface with subcontractors. Professional preparation for the construction engineer includes: a strong background in design (structures and components), economics, business matters, labor relations, and interactions with people. Interactions with subcontractors and craftsmen—carpenters, pipe fitters, electricians, plumbers, and so on—are often crucial to completing a project on schedule and within cost.

The most difficult problems of construction engineers require a strong technical background, but their ability to work with people generally decides success or failure of a project. The ultimate capability of the construction engineer requires experience and judgment which can only be obtained by actual practice.

Operations and Maintenance. After a structure—building, dam, bridge, or system—has been completed, it must be maintained and operated by someone with unique capabilities. Such a person may be called *plant engineer* or *operations engineer.* Operations include: maintenance of the structure, grounds, equipment and utilities; setting up and regulating facility equipment and automated machinery; optimizing operating costs; keeping the environment acceptable; and phasing in new equipment when needed.

Professional preparation of the plant engineers, or operations engineers, includes a broad background in the functions of engineering, ideally in most of the engineering disciplines. They must deal with operating personnel, vendors, community leaders, and other professionals (lawyers and doctors, for example). Often regulations imposed by governmental agencies or an internal board of directors may require significant time and effort.

Plant engineers plan new facilities; supervise construction if done in-house; select and install equipment; allocate space; and are responsible for the overall safety in the facility. They usually have crews of craftsmen and technicians to carry out the needed functions. Operating cost containment is generally a crucial role of the plant engineer. This routinely entails monitoring utility costs and energy losses from the structure; maintaining the environment (lighting, heating, ventilation, air-conditioning) within acceptable standards; and protecting the facility and operating personnel.

Successful operations engineers are not so much dependent upon esoteric mathematical concepts and scientific principles as they are on being able to optimize the output of machines and the input of operating personnel. The operations engineer is analogous to the conductor of a symphony, making sure that each person carries out the assigned tasks. On-the job training should be supplemented in professional preparation by knowledge of labor relations, psychology, economics, and interactions with people.

In general, the plant engineer is responsible for the smooth operation of the facility, including the safety of personnel.

Testing and Instrumentation. Some would argue that testing is not a separate engineering function since it is done at all levels of research, development, design, and production, sometimes even in operations. It is so important, however, that it deserves separate note. During research, the testing that is done falls into the area of experiments to examine the validity of hypotheses or wild ideas. At the development stage, it is usually necessary to test prototypes of components and subsystems as well as new processes. Clearly, a product must be tested periodically during its manufacture in order to assure its quality.

The responsibility for conducting some of the tests in the engineering spectrum rests with test engineers. They must be able to establish the test protocol, setting the test parameters as well as the quantities to be measured. Statistical standards are important to the test engineer, requiring that an adequate number of tests be conducted in each sequence of data collected. The data must then be analyzed with appropriate conclusions drawn.

Quality assurance (*QA*) *engineers* are responsible for the *quality control* (*QC*) in a manufacturing or construction operation. The requirements involve periodic inspections in addition to maintaining adequate control procedures for assuring that the quality sensed at periodic junctures is held fast.

Professional preparation for the test engineer includes: a sound background in the basic sciences and the engineering sciences; keeping current in measurement techniques; a strong base in probability and statistics; knowledge of calibration methods; and familiarity with pertinent codes and standards which govern the products and/or structures and the test procedures.

Test engineers are often called upon to specify the instrumentation that is required in manufacturing operations, not just in the testing and sampling processes. They are normally better able to provide instrumentation details than the research, development, design, or production engineers whose responsibilities are much broader but less attuned to the intricacies of measurements and control.

Sales and Marketing. At the outset, it should be noted that all other engineers usually claim that sales engineers promise more than they can deliver. For this reason, it is important that those who are in marketing keep in touch with their colleagues that are producing the things they sell. In order to maintain personal and organizational integrity, the sales engineer should not sell anything that is not useful to the customer.

The sales engineer is expected to have a broad engineering knowledge, be intimately acquainted with the product that is being sold, and understand the needs of the customers. Contrary to some pundits, being a responsible sales engineer is not always easy. It requires being alert to anticipated changes in models, government regulations, and new materials which might be used to advantage. It requires knowing the competitors' products about as well as one's own.

The responsible sales engineer might even sell a competitor's product on occasion. This brings up the concept of being a representative of several manufacturers, complementary or otherwise. This is often done in the case of after-market parts and components where replacement units may be built by a number of manufacturers, say in motor vehicles and farm machinery. The manufacturers' representative needs an even broader background than a sales engineer, who deals only with proprietary products.

Professional preparation for the sales engineer is first and foremost being equipped to work well with people. This requires a background in the social sciences, psychology, and business as well as a clear understanding of the fundamentals of engineering. Sales and marketing seminars and workshops are a must if one is to keep up with the competition. Anything that can be done to improve one's personality and confidence is a plus. Speech courses and leadership conferences usually help. But most of all, the sales engineer must enjoy people and believe in the product that is being sold in order to succeed.

Management. The management function of engineering may be viewed with respect to the other functions by considering their roles (5). Research determines *if* a thing can be done; development determines *what* can be done; design and production determine *how* it will be done. But management must decide *whether* to do it at all. The best overall attributes of all functions of engineering are brought to bear in management.

Management is always crucial to the success of research, development, design, and production or construction. Since the managers at this level must have strong technical abilities, it is logical then that managers arise from the functions of their expertise. As they advance in management activities, they usually become less involved in details of technical matters. Their attention is diverted to the overall operation of the organization, as well as to matters that involve all of the engineering functions.

In the past, many managers—including those who may be executives—were selected with backgrounds in business, law, or the social sciences. Today there is an increasing trend in industry and government to choose managers who have an engineering background, perhaps because of the increased complexity of our products and processes. This is especially true in industries which are involved in advanced technology and large volume manufacturing. The principal advantage that engineers have over professionals from other backgrounds is their methodical approach to problem solving. No one knows better than an engineer that a problem cannot be solved until it is well-defined, even if nebulous assumptions must be made at the outset.

The basic principles of management are the same without regard to the operation, whether the company is building microprocessors or drilling for oil. The objective is to use the resources of the organization to the best advantage in a competitive economy. The company resources will depend upon the nature of the business.

The engineer in management must continually make decisions in the optimal use of facilities, including equipment, capital, and personnel. The decisions may be touchy on occasion—for example, when a decision is made to down-size staff in order to buy and utilize a sophisticated automated machine. Such decisions are often made on the basis of return to the stockholders or taxpayers.

Most managers that come from engineering need additional training in the business aspects of the operation. Development of the needed skills may be facilitated via Saturday management programs at local universities or by specialized short courses, say in cost accounting. It is generally agreed, however, that such deficiencies can always be augmented more easily than a person with a nontechnical background can learn enough about the technology of the operation.

Clearly, the manager must have a variety of blended skills from technology and business. This is especially true in the aerospace and electronics industries which are highly automated or computer intensive. One bright spot for the electrical engineer is that microprocessors drive the world!

The professional preparation of an engineer in management parallels that of other engineers in the fundamentals of engineering. Having an aptitude for working with people is the attribute that commonly leads to an engineer being selected for management. Being able to sell oneself and the organization's product or service is central to success. The manager must be able to lead teams of multitalented personnel, accepting many of their nuances and channeling them into a cohesive unit. Successful managers must care for people, be sensitive to their personal welfare, and share their successes without placing themselves in an intellectually superior position.

Any engineer who has the ability to apply engineering principles in the supervision of large numbers of people while they expend huge sums of money can qualify to be a manager of an enterprise. This is without regard to one's individual discipline or engineering function background.

In addition to being responsible to the stockholders and organizational personnel, managers are also responsible to the general public. It is not acceptable to make more money for the stockholders if the organization pollutes adjacent streams or the air in the community.

Since managers normally speak for the organization, they must present a good appearance and appeal to a variety of publics. Their written and verbal communications skills must be excellent in order to succeed. Nowadays, the way one projects on television is very important in some organizations.

Managers have the ultimate responsibility for (a) recruiting and training personnel, (b) leading in the formulation of the objectives of the organization, (c) the acquisition of materials and equipment, and (d) optimizing the organization's capital. They will be dependent upon key personnel for input required in the decision making process. This dependency determines how the business is organized, who reports to whom, and so on.

Systems. The concept of systems engineering has come to the fore in recent years. Notably in the space program, all engineering disciplines and functions had to be brought together systematically in order to achieve the results of an extensive project—reaching the moon and beyond.

The concept of systems engineering can be thought of as a super management tool. There are no new principles—only methodical checks and balances, schemes for bringing experts together, and optimization via tradeoffs.

Teaching. Teaching is a unique function of engineering. In a way it subsumes all of the other functions of engineering. More than in any other engineering function, teaching offers the practitioner the best opportunity to continue learning and influence newcomers to the profession. In order to be successful, engineering teachers must remain at the forefront, keep up with all of the newest developments, and be able to translate them to a variant audience.

Today's university faculty members are more than transmitters of knowledge. They are intimately involved in the acquisition of knowledge via research and making it applicable by development in the laboratory. Faculty members' research leads to the publications which are generally the most esoteric and universally applicable throughout the technological spectrum. That this is true derives from *academic freedom* and not being bound by proprietary interests. Fewer patents are granted to faculty members, however, than to industrial practitioners since patents normally arise from proprietary interests.

Engineers who teach have a greater freedom to select their areas of concentration than other engineers. In general, engineering teachers select their own research areas for investigation, establish their own standards of performance, and enjoy greater flexibility than other practitioners. These freedoms require an unusual measure of initiative, personal esteem, enthusiasm, and perseverance. Teachers commonly rub shoulders with other professionals who are experts within their own areas, which provides fodder for further learning and motivation to emulate the best.

To be a successful teacher requires mastery of one's subject and the ability to communicate. Engineering teachers usually come from the top quartile of their classes. They can do anything. The pundit who says that "those who can't do anything else, teach" is just wrong!

Professional preparation for teaching requires an advanced degree(s). The doctorate—Doctor of Philosophy, Doctor of Science, Doctor of Engineering—is now considered the required degree for one entering teaching. This is based upon the special competence that comes from original research done at an advanced level, which only comes after developing an extraordinary measure of personal discipline and perseverance. Ideally, one who goes into teaching should be acquainted with educational methods and have a mastery of communication skills.

Engineering teachers routinely participate in two other functions of engineering: research and consulting. Research is their vehicle for enlarging the borders of their areas of interest and expertise. It also provides an avenue for publication, which is now expected of those who teach in engineering schools. And it provides a way for those with common interests to come together in symposia and forums to share their findings with others. The expertise developed in their push to excel then makes them attractive as consultants to industry and commerce as solvers of unique and intractable problems.

Consulting. Consulting engineers are recognized as such by their ability to solve difficult problems. They are often called when others have failed to solve existing problems. They generally act as a source of information for a variety of industrial and governmental organizations. The connotation of the title *consultant* suggests specific skills or expertise brought about by extensive education and experience. A new graduate is rarely asked to be a consultant!

Industries seek consultants to design and develop new and unique products and processes and to solve problems that their own personnel have not been able to handle. Some governmental agencies seek consultants to ply their expertise to specialized tasks and to bring an outside view to projects. The legal profession is increasingly using engineering consultants to investigate failures of machines and processes and to testify in the courts in resolving conflicts that have resulted in litigation—commonly in products liability matters, personal injury, patent infringement, and business practices.

In every consulting assignment, the consultant is expected to quickly evaluate the matter, estimate the effort required to remedy the problem, and offer solutions which may solve the problems or resolve the issues. Recommendations are often sought which provide alternatives for managers. In some cases, financial implications have to be factored into the proposed solutions.

Engineering consulting usually begins individually, although there are a number of companies which specialize in offering consulting services. Some consulting firms offer a wide variety of services—including design and construction of buildings and public projects; water treatment plants; airports, chemical facilities; oil refineries; and the operation of private ventures or public services.

Profession preparation to be an engineering consultant requires development of an extraordinary expertise. The best preparation is being well-grounded in the fundamentals of engineering and having the ability to extrapolate those basics to a variety of circumstances. Consultants are rarely called upon to solve problems that they have seen before. The problems are unique or the circumstances differ, requiring that fundamental principles be brought to bear in reaching a solution.

A most important attribute of the successful consultant is communication skills, written and verbal. Most consulting projects require a written report in addition to verbally reporting to those who have engaged the consultant. Clear thinking, while applying engineering basics, and verbal skills are especially important in consulting in the legal arena. The choice of words and the intonation of the presentation may influence the judge or jury in a key point of a trial.

Successful consultants must be adept at business. Their livelihood depends upon selling their services and assuring the financial success of their work.

The best preparation for being a consultant is knowledge and experience, knowledge and experience, knowledge and experience!

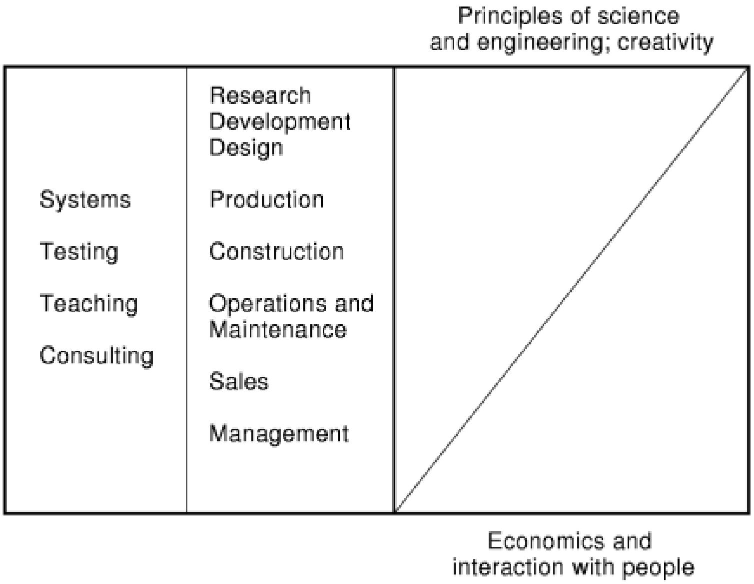

Fig. 2. Functions of engineering. A qualitative representation of how the functions of engineering relate to the Principles of Science and Engineering (top abscissa, heavy on technical aspects) and to Economics and Interactions with People (bottom abscissa, heavy on societal interactions).

Other. Graduates of engineering schools sometimes go into other professions. Business gets the largest percentage of those who step across the border from engineering with a number pursuing Master of Business Administration (*MBA*) degrees. The MBA is sometimes viewed as a shortcut in preparing those engineers who want to go into management.

The next larger number of engineering graduates go into law. Their engineering backgrounds serve them well in the logic that is necessary in the preparation of cases. Engineering fundamentals are a tremendous benefit to attorneys who practice in patents, personal injury, and products liability.

Engineering graduates are increasingly going into medicine. This is a boon for the area of biomedical engineering. In this area, engineers are better equipped to make major contributions to medical instrumentation, prosthetic devices, and biofeedback systems. Their knowledge of materials, motion, and structures augments that learned in medical school, facilitating their treatment of special maladies.

Engineers are also going into banking and commerce more than in the past. Their backgrounds make them well-suited to evaluate business ventures, especially those entailing technical matters.

In short, engineering education and experience equip individuals for any endeavor in life. The ordered approach to identifying problems and solving them in a methodical fashion contributes to success in any career.

Summary

The engineer is a problem identifier and solver, whether technical, socioeconomic or otherwise. The problems range from highly technical research, dependent upon theoretical principles and creativity, to the less technical, more people-oriented management challenges which are centered on people and capital. Figure 2 illustrates the functions of engineering, in a qualitative fashion, as they relate to engineering principles and business aspects of the engineering spectrum. Note that the figure depicts the bridging functions of systems, testing, teaching, and consulting as spanning the other functions.

Professional preparation for engineers in all functions of engineering have a common beginning to career development—the basic engineering degree. But that is only the beginning, as suggested by the term *commencement* applied to the graduation ceremony. The engineer must continue to learn via professional development activities—additional formal education, short courses, membership in professional/technical societies, workshops, professional conferences, and other means of education and training. But the best preparation is personal study and development via interfacing with others who know more than ourselves.

The spectrum of activities in the engineering profession is very broad. Engineering touches every other aspect of life. Electrical engineering is crucial to all engineering disciplines and to every engineering function.

BIBLIOGRAPHY

1. Accreditation Board for Engineering and Technology, *Criteria for Accrediting Programs in Engineering in the United States*, Baltimore, MD, 1996–1997.
2. G. Maslow, *Motivation and Personality*, New York: Harper and Row, 1970.
3. G. C. Beakley, D. L. Evans, J. B. Keats, Engineering: An Introduction to a Creative Profession, 5th ed., New York: Macmillan, 1986.
4. S. G. Walesch, *Engineering Your Future: Launching a Successful Entry-Level Technical Career in Today's Business Environment*, Englewood Cliffs, NJ: Prentice-Hall, 1995.
5. J. C. Martin, The Successful Engineer, New York: McGraw-Hill, 1993.
6. R. B. Landis, *Studying Engineering: A Road Map to a Rewarding Career*, Burbank, CA: Discovery Press, 1995.

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