

# Chapter 1

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## Entrepreneurial Engineer: Ready for the 21st Century

### 1.1 21ST-CENTURY ENGINEERS MOVING AT INTERNET TIME

The Internet. Global markets. Time compression. Competitiveness. We increasingly live in a connected world where packets of information whiz around the globe at the speed of light, carrying the electronic equivalent of letters, money, contracts, designs, or other work product between actors located anywhere on the planet. It is against such a backdrop that engineers plot a course for a life of rewarding, productive work, but it is a world vastly different from the one faced by engineers even a few short years ago. Not long ago, the engineer of the Cold War prepared for work by immersing himself in a narrow technical discipline, expecting to work his entire career for one of a small number of gigantic employers on some specialized subsystem of a defense-related or smokestack megaproject. Today's engineer is on a different planet. He or she faces a life filled with multiple project assignments with an almost interchangeable array of employers, clients, startups, and established firms; these assignments require an extraordinarily broad set of technical, business, and interpersonal skills performed as part of ever-changing and shifting interdisciplinary teams.

This change in work life has been as rapid as it has been dramatic, and the job here is to survey those nontechnical skills essential to being a successful engineer in the 21st century. As opposed to the Cold War engineer, we call the ideal engineer of our times an *entrepreneurial engineer*, and here we interpret the word *entrepreneur* quite broadly.

In the traditional sense of the word, today's engineer *is* more likely to find him or herself as part of a startup, replete with 13-hour workdays, a Blackberry, and stock options. But even when today's engineer works in more traditional settings, he or she is likely to find that both the job itself and effective career management require a more venturesome attitude and approach. Increased competition places enormous pressure on companies to continue to improve and

innovate in creating new product lines, acquiring new customers, adopting new technology, and implementing better business practices. In larger companies, words have been coined to describe this need, *intrapreneurship* or *corporate entrepreneurship*. However, this pervasive orientation toward opportunity, innovation, and reward is now also necessary in the management of one's own career.

In times past, employers took a paternalistic view of employees, managing their remuneration, health benefits, and retirement over the course of an entire career. Those days are largely gone, and today's engineer must take charge of his or her career by seeking a challenging sequence of work experiences that help build a marketable portfolio of diverse skills. Entrepreneurial engineers meet the challenges of changing times as opportunities, seeking challenging and rewarding work together with an appropriate balance of intellectual, financial, professional, and personal growth.

## **1.2 ENGINEERING EDUCATION, COMMON SENSE, AND THE REAL WORLD**

Common sense and general education prepare today's engineers for some of the challenges of our fast-paced times, but the predominant emphasis of an engineering education on the technical side of the ledger is, in one sense, misleading. The average engineer studies many long years, plunges into the real world, and finds that a tough part of the job was left as an exercise to the reader. While engineering school spends a majority of the time on difficult technical subjects—science, mathematics, and engineering—these important topics may constitute less than half of an engineer's working day. Moreover, career success as an engineer, while tied to technical prowess, may have as much to do with your ability to communicate with co-workers, sell your ideas, and manage your time, yourself, and others. These crucial nontechnical skills will determine your career success—and your happiness—more often than will your ability to manipulate a Laplace transform, code a Java object, or analyze a statically indeterminate structure.

Of course, this is not to belittle technical skills; after all, engineers wouldn't be engineers unless they knew a great deal about technical matters. Engineering education must spend a preponderance of its time on technical matters to bootstrap the engineer into a world of increasingly complex and changing technology. On the other hand, preparing for difficult organizational and people-related challenges helps engineers to be more effective throughout their careers.

Another side effect of the necessary concentration on technical subjects in an engineering education is that sometimes engineers think of nontechnical subjects as soft or easy—mere common sense. But the human and business sides of engineering are extraordinarily challenging and have the potential to be extraordinarily rewarding. Although many of the key topics may be classified under the category of common sense, actually putting them into practice consistently and regularly requires practice and hard work.

## 1.3 TEN COMPETENCIES FOR THE ENTREPRENEURIAL ENGINEER

So perhaps we agree that an engineer needs to be skilled in matters nontechnical. But what areas are particularly important to understand? Here we proceed from matters of individual concern, to interpersonal matters, to matters of team and organizational significance. Specifically, an entrepreneurial engineer should:

1. Seek the joy of engineering.
2. Examine personal motivation and set goals.
3. Master time and space.
4. Write fast, revise well, and practice BPR (the elements of background, purpose, and road map).
5. Prepare and deliver effective presentations.
6. Understand and practice good human relations.
7. Act ethically in matters large, small, and engineering.
8. Master the pervasive team.
9. Understand leadership, culture, and the organization of organizations.
10. Assess technology opportunities.

The importance of each of these is briefly reviewed in what follows.

**Seeking the Joy of Engineering** The terms *joy* and *engineering* aren't often used in the same sentence, which is a shame because a proper understanding of engineering leads us to understand how multifaceted the learning and practice of engineering can be. Some of the confusion is the result of two historical inversions in perspective, and another portion of misunderstanding comes because engineering is wedged between business and science. A closer reading of history and understanding the fundamental tug-of-war that engineers face help us understand the essence and joy of being an engineer more deeply.

**Examining Personal Motivation and Goal Setting** Understanding what motivates a person in his or her professional life is fundamentally important and difficult. Many people think that they simply work for the money, and indeed financial remuneration can be a factor in career choices, but a more reliable guide to a life of fulfilling work is found in the term *engagement*. Instead of seeking money directly, another approach is to seek work that is so engrossing that time flies because it is so much fun. Incidentally, the fun of engagement can lead to sufficient time on task and professional growth that the person also gains a substantial income along the way.

**Mastering Time and Space** Understanding personal motivation and setting goals may be thought of as the strategic level of managing yourself. Time and storage management is the tactical level of being personally organized. How one

spends one's day and where one puts one's stuff are basic to sustaining a high level of personal productivity, but a haphazard approach to these matters is all too common. Fortunately, significant improvements in time utilization can be achieved through the development of a few key habits. Primary among these are the disciplined use of (1) a calendar, (2) a to-do list, and (3) a systematic filing system (both paper and electronic).

**Writing Fast, Revising Well, and Practicing BPR** Writing is as popular with many engineers as going to the dentist, but entrepreneurial engineers spend a fair amount of their business days writing. With a cubicle piled high with writing projects, the last thing the entrepreneurial engineer needs is a case of writer's block, but common writing maladies can be traced to difficulties in writing process, content, or both. Writing process can be improved by separating writing from revision, and we examine a number of specific techniques including freewriting, quick planning, and cut-and-paste revision to help us separate these two writing functions. Writing content can be improved by understanding three key elements that are common to almost all business writing. These elements—background, purpose, and road map, or BPR for short—can and should be iterated at different levels of a document.

**Preparing and Delivering Effective Presentations** PowerPoint presentations are now a way of business life, but giving a slide presentation is different than giving a speech. By preparing and treating Powerpoint slides as note cards we share with our audience, the process of preparing and delivering a presentation is simplified. The rules of presentation organization are remarkably similar to the BPR rule of effective writing, and indeed good writing leads to good presenting and vice versa. Add some guidelines and concern for effective slide layout and presentation delivery and the entrepreneurial engineer is well on the way to becoming an effective presenter.

**Practicing Effective Human Relations** Formal communication skills such as writing and presenting are a good place to start in developing interpersonal skill, but effective human relations are especially important in an increasingly interconnected world. The world of people can seem a lot less predictable to engineers accustomed to Newtonian models of physical systems, but engineers can find modeling guidance—and success in their relationships—by using a variation on the golden rule we call the other-eyes principle. This principle recommends that we predict or anticipate the behavior of others by considering our own reaction to a similar set of circumstances. Although not infallible, such modeling is often a good first-order guide to predicting the response of others. Along the way, we consider the importance of questions, salesmanship, praise, and passion in successful interpersonal relations. The downside of criticism is visited as is the need for admission of wrongdoing and apology.

**Acting Ethically in Matters Small, Large, and Engineering** In some ways, the whole topic of ethics may be viewed as a logical extension of human

relations, and the golden rule in both of its major forms is a useful entry point to the topic. Thereafter it is useful to consider a number of sources of ethical thought and reasoning, including religious or cultural norms, an innate moral sense, maximization of societal utility, and consistency. Each of these viewpoints is helpful, and each has been challenged by ethical skeptics over the years.

In moving from ethical theory to ethical practice, a key question is why people who accept a set of moral principles fail to do the right thing, and self-interest, obedience to authority, and conformity to the group are highlighted as major culprits. With this in mind, we suggest that practice on small matters is the surest way to doing the right thing when the big issues arise. In other words, our approach seeks success in *microethics* or ethical behavior in small, everyday matters. If we are unable to behave ethically when the stakes are small, it seems unlikely that we will be able to behave ethically when the rewards of unethical behavior are great.

This logically leads to a fuller consideration of professional ethics and the larger *macroethical* challenges of being an engineer. Our examination of engineering ethics concludes by considering (a) what a profession is and (b) two contrasting engineering codes of ethics.

**Mastering the Pervasive Team** Teamwork has become integrated into the fabric of modern organizational life as a result of the quality revolution, but effective teamwork is difficult as many of us know from our early experiences with “group projects” in school. In group work, it becomes difficult to coordinate inter-related pieces of a project, and individuals can sometimes be uncooperative or even shirk their responsibilities. A clearheaded approach to teamwork acknowledges these difficulties and then designs team rules, discussion protocols, and other procedures to facilitate effective meetings and team activity. Our approach combines quantitative and qualitative models in a quest to create more effective teams.

**Understanding the Leadership, Culture, and Organization of Organizations** Managing ourselves effectively and working well on teams are important, but understanding organizations and leadership at a somewhat higher level is also important to the entrepreneurial engineer for two reasons. First, knowing good organizations and leadership helps us pick the best work opportunities. Second, an orientation toward opportunity often results in the need to lead an existing or new organization.

A common feature of good organizations is that they think good thoughts about their employees; bad organizations tend to distrust theirs. This dichotomy is well reflected in modern theories of organizational behavior. Good companies and good leaders have been studied empirically on a comparative basis, and a number of recent studies are examined with an eye toward using their practical suggestions to better understand good companies, cultures, and leaders.

To understand organizations it is also helpful to know the economics behind their formation, and this leads to the topic of *transaction costs*. This in turn leads

to a discussion of the growing trend toward more frequent job changing and free agency, and this leads us to think in terms of our network and our portfolio of accomplishment.

**Assessing New Technology Ventures** The entrepreneurial engineer, whether in a startup or part of a larger corporation, is increasingly being asked to help assess and pursue technology opportunities. Technology opportunity assessment and planning are challenging activities that require the entrepreneurial engineer to imagine new opportunities, match them to markets, and determine whether they are both technologically and financially feasible. As an educational experience, working on a technology opportunity assessment or a business plan is the quickest way for the entrepreneurial engineer to bootstrap him- or herself into understanding the importance of sustainable competitive advantage, customers, marketing, pricing, costs, and value at the core of the business side of engineering.

These 10 competencies are at the heart of what entrepreneurial engineers need to master to be effective in a faster moving world of deals, teams, startups, and innovating corporations.

## 1.4 THREE PRINCIPLES

The entrepreneurial engineer has many nontechnical skills to master, but at their root, these manifold skills of managing time, space, people, and money can be reduced, in many cases, to just three recurring principles:

1. Seek engagement.
2. Create first; criticize later.
3. Analyze through the eyes of others.

In the remainder of this section, each of these is discussed briefly in turn.

**Seek Engagement** We have already dealt briefly with *engagement*—finding and doing things you enjoy profoundly—as a key skill to understanding personal motivation. Fortunately, an engineering education provides a broad platform of technological and general knowledge from which to seek engagement, and the profession itself is sufficiently multifaceted that it can comfortably accommodate a wide range of motivations and personal preferences.

**Create First, Criticize Later** A second principle that reverberates through the 10 core competencies is that of *creating first, criticizing later*. In any creative activity, whether it be designing, writing, presenting, or problem solving, it is important to get many ideas out on the table to permit their cross fertilization and to stimulate additional associations. School learning, with its emphasis on *convergent thinking*—applying what has already been discovered—discourages the *divergent* or *lateral* thought required for excellence in all creative activities. Writing and brainstorming are fairly obvious activities where this principle

applies, but the principle is general in its scope of application, and should be kept in mind in all creative endeavors.

**Analyze and Design Behavior through the Eyes of Others** The last theme running through the 10 competencies is *analyzing and designing behavior through the eyes of others*. The economist sometimes has the luxury of imagining a “Robinson Crusoe” economy where a single individual’s wants and needs are met by his or her own efforts, but almost all human activity is carried out through a messy mix of cooperation and conflict with others. Efficiency requires that we maximize the former and minimize the latter; to do this, we must understand the motivations of the other individuals involved. It is interesting that we are pushed in this direction not by altruism but by pursuit of personal effectiveness. It is also interesting that our study of others often results in our becoming better—marginally more objective—observers of our own behavior.

Although it is impossible to capture the complexity of all human interaction in a few short words, learning and using the three principles can often lead to useful guidance in new or unanticipated situations.

## 1.5 THREE CAUTIONS

Engineering teaches us to apply models in an almost promiscuous fashion. Engineers model structures. Engineers model circuits and control systems. Engineers model manufacturing workstations, assembly lines, even whole factories. But when it comes to modeling creative activity and human interaction, we need to be somewhat more cautious in our modeling. Specifically, three cautions must be exercised.

**Be Realistic in the Application of Ideals** Many nontechnical skills are discussed in terms of *ideals*. Doing this has benefits and risks. The primary benefit of using ideals is that we can easily define a target by which we can measure our own behavior and make adjustments. The primary risk is that no one can live up to ideals all the time. My introduction to the literature of success, which came during my first job, led to frustration; I read many books about business and management and saw that my company and my clients’ organizations were far from the ideals discussed. Focusing on these discrepancies led to unproductive rounds of playing “ain’t it awful.” This is a rookie’s mistake.

One should be sensibly realistic in applying ideals. It may be all right to press for your own top performance or that of an organization that reports to you, but applying ideals to others who do not share your vision is a prescription for unhappiness and disappointment. Moreover, as pointed out elsewhere (Fritz, 1991), you should select ideals with considerable care, as it is possible to become paralyzed by conflict between what the ideals promise and what is actually possible.

**Mastering the Obvious Isn’t Easy** Engineering students often think of practical nontechnical matters as being “common sense” or “obvious,” but just because some skill is superficially obvious doesn’t mean that mastering that skill

is easy. The problem here is the inherent complexity of many nontechnical skills. For example, writing is a many-layered topic. At root, writing is about such basic skills as grammar and punctuation. At the next level, it is about sentence structure, flow, and paragraphs. At yet another level, it is about overall organization and presentation of material in a logical yet interesting fashion. With so many levels requiring adequate performance, it is difficult to be proficient on all of them simultaneously, and there is always room for improvement on one of them.

In talking about another complex skill—swinging a golf club—champion golfer Ben Hogan wrote the following (Hogan, 1957, p. 30):

*It may be seen that we have gone into unwarranted detail about the elements of the correct grip [of a golf club]. This is anything but the case. Too often in golf, players mistake the generality for the detail. They think, for example, that overlapping the finger is the detail and so they do not pay sufficient attention to how they do it. Or they confuse an effect (which can be quite superficial) with the action (the real thing) that causes the effect.*

Like golf, the core nontechnical competencies required of the successful entrepreneurial engineer are sufficiently complex that there are many subtle details or facets to learn; it is impossible to learn them in a single lesson. Moreover, it takes conscientious practice to maintain a skill once it has been developed. Just as golf professionals return over and over to the fundamentals of grip, stance, swing plane, and so on, so too must we return repeatedly to the basic skills and principles that help make us effective in our professional lives. And just as professional athletes take a positive attitude toward continual improvement—a philosophy the Japanese call *kaizen*—it is especially important for entrepreneurial engineers to adopt a philosophy of continuing professional development.

**Engage the Material and Put It into Practice** Discuss a technical problem with data, equations, and graphs and a group of engineers will become engaged and animated. Discuss a personnel problem with interpersonal drama, tension, and ambiguity and that same group's eyes will glaze over. And unfortunately the personnel problems are getting in the way of our doing the fun technical stuff as much and as well as we would like.

No one will agree with this text on all matters, but when you find an idea, suggestion, or tip that makes sense, why not try applying it to your work? When you disagree with a topic or approach, why not read what others have to say about the same subject? The bottom line of this book is that there is more to engineering than technical skill, and engaging the material herein, questioning it, and putting it to practice is a good start toward becoming a more entrepreneurial engineer.

## EXERCISES

1. Make a list of the five people who have influenced your life most directly and the ways in which they changed the course of your life to date.
2. Make a list of between one and five living public figures you look to as role models. What elements of their character do you wish to emulate. List at least one specific experience or event about each figure that you particularly admired.



3. Make a list of between one and five living public figures you least admire. What elements of their character do you find objectionable. List at least one specific experience or event about each figure that exemplifies your concern.
4. Read a bibliography of an historical figure you admire. Rate the person on his or her (1) character, (2) interpersonal dealings, (3) communications ability, (4) organizational capability, (5) balance between family and work, (6) technical skills, and (7) leadership ability. List a single anecdote from the person's life that is most telling of his or her nature as a person.
5. List the reasons why you became (are becoming) an engineer. If you had the decision to do over, would you make the same decision? Why or why not? In what ways has the decision turned out better than you expected. In what ways have you been disappointed by the decision.
6. What experiences to this point in your life have most influenced your ability to work with others? Make a list of those experiences and list the primary lesson or lessons of each experience.
7. Make a list of your top three strengths. List the ways in which those strengths connect to your career or life decisions to date. List five ways in which you could build on each of those strengths.
8. Make a list of your top three weaknesses. List the ways in which those weaknesses have limited your career or life progress. List five ways in which you could help overcome each of those weaknesses.
9. Make a list of three companies or organizations you admire. Explain your choices in a short essay.
10. Make a list of three companies or organizations you do not admire. Explain your choices in a short essay.