CHAPTER

5 Overcoming Obstacles to Creativity and Innovation

Patience and perseverance have a magical effect
before which difficulties disappear and obstacles vanish.
—John Quincy Adams, sixth US President

Objectives:

After studying this chapter, you will be able to:

- Describe seven likely obstacles to individual and organizational creativity and innovation
- Illustrate at least one remedy for each obstacle
- Apply twenty questions to help you and/or your team more thoroughly define the potential positive and negative impacts of your creative/innovative idea so that you can proactively move forward

5.1 OBSTACLES TO STOP YOU OR ROADBLOCKS TO BE REMOVED?

This chapter addresses the resistance your creative ideas will often encounter and offers remedies. We begin by describing internal and external obstacles; the remainder of the chapter discusses seven obstacles in depth and how you can overcome them.

5.1.1 External Obstacles

On the surface, being individually and organizationally creative and innovative seems very desirable, like favorite desserts, high grade point averages, and long weekends.

Who wouldn't want those things? The popular media frequently extols the need for and benefits of creativity and innovation. Leaders and managers from all sectors of society, including engineering, call for more creativity and innovation, and many imply that they are setting the pace.

However, based on my studies and experiences that focus on the world of engineering, I believe that only a miniscule fraction of engineering firms and engineering-oriented government, academic, volunteer, and other entities take a proactive, system-wide approach to creativity/innovation. Their visions, missions, recruitment, marketing, and other public statements aside, very few such organizations embrace creative/innovative cultures. As a result of their inattention, if not indifference, they are missing much, taking passive or reactive positions, and accepting surviving or risking dying. They could be thriving.

That said, I recognize the good news that there are some of you who, by virtue of personal qualities (e.g., see Chapter 6), will create and innovate no matter what the prevailing environment says. However, my mission (of which this book is a part) is to help many more engineers, and thus their organizations, be even more creative and innovative. A rising tide lifts all boats.

As a young person, whether an engineering student or practitioner, you see, understand, and quickly use new technologies. Accordingly, you may view creativity and innovation very positively and wonder how entire organizations could fail to endorse it or how some individuals could resist it. By raising the issue of obstacles, I do not want to diminish your enthusiasm for creativity and innovation, but rather I want to expose you to some realities that you will need to address if you wish to be creative and innovative. Forewarned is forearmed.

Resistance to establishing a creative/innovative atmosphere and even a tendency to discourage creativity and innovation are understandable, but not productive in the long run. We can collectively offer many reasons, some very well-intentioned (as will become apparent in this chapter), for those oppositional viewpoints. When faced with a challenging IPO, taking a creative/innovative approach presents risks and incurs up-front costs. However, those reasons, risks, and costs often do not tell the whole story.

You've probably noticed as you work through this book that creativity and/or innovation, when they are cultivated and thrive, often yield many and varied benefits for various individuals and organizations and, more importantly, those they serve and society at large. Table 5.1 illustrates this fact by alphabetically listing most of the examples of creative/innovative systems, facilities, structures, products, processes, and approaches that are at least mentioned in this text. The table notes the sections in which they appear and identifies one major benefit of each, recognizing that most have multiple benefits. If a particular item interests you, refer to the indicated section; if you want more information, use the source or sources cited in that section.

Section 1.4 offered reasons that engineers in the United States and other well-developed nations will need to be more creative and innovative. They are meeting grand challenges, doing more conceptual work because algorithmic work is moving to increasingly capable personnel in developing countries, placing more emphasis on pursuing opportunities, addressing wicked problems, practicing better stewardship with the intellectual gifts of student and practicing engineers, and the enjoying satisfaction of doing what has not been done.

In my view, the positives of creativity and innovation offset the negatives. Those who share that view should be aware of the obstacles to creativity/innovation so that they can individually and organizationally deal with them and help themselves and others reap the benefits. What appear to be impenetrable obstacles are often merely

Table 5.1 Many and varied examples of creative/innovative systems, facilities, structures, products, processes, and approaches, along with their benefits, are described in this text.

Creative/innovative system, facility, structure, product, process, service, or approach	Section(s) in book where described	A major benefit
Accelerated bridge construction (ABC)	8.6.2	Greatly reduces traffic disruption
Agriculture: precision	8.3	Reduces cost and risk
Alternating current systems	6.8.3	Enables community-wide electric power
Art museum: Milwaukee, Wisconsin	7.2.3	Unique roof wings that open to the sky
Automobile assembly line	4.3.2	Reduces cost per vehicle
Baby incubator	6.8.1	Saves lives in developing countries
Bar code	4.11.2	Reduced retail costs and increases sales
Barbwire	7.2.5	Livestock control
Book proposal process	4.11.1	Generates ideas for content
Books: Dr. Seuss	6.8.3	Enjoyable children's books
Borrowing geological concepts	4.3.2	Stimulates theory of evolution
Brain-imaging techniques	2.15.3	Reveals how the brain functions
Bridge reuse: temporary	8.6	Reduces public impact during construction
Brooklyn Bridge	6.8.4	First use of twisted wire cable
Cable: twisted wire	6.4.1	Enables design and construction of suspension bridges
Calculator: pocket	6.3.5	Easy access to fast computation
Cardiac pacemaker	3.6.1	Extends life
Cold call ideas: generation	4.7.2	Provides content for presentation
Cotton gin	8.3.1	Revolutionizes cotton production
Course scheduling assistance by novice	4.6.3	Frees department heads to work on higher-level tasks
Desalination	8.5	Expands supply of potable water
Desktop metaphor: Microsoft	4.3.3	Basic structure for personal computer use
Disneyland	4.3.3	First in a series of fun and educational theme parks
Door handles: extra	6.2.2	Accomodates children
Drainage laws	6.3.4	Protect property
Drawings of the inside of the human body	6.3.2	Greatly improves understanding of the body's elements and functions
Energy conservation principle	6.4.2	Improves understanding of the natural world
Enigma code: breaking it	4.6.7	Saves many lives
Evolution: theory of	4.3.2	Improves understanding of the natural world
Facebook	4.3.3	Popular social media
Floor cleaner: Swiffer	4.8.2	More efficient floor cleaning
Fluid flow in open channels: Manning Equation	4.3.4	Channel design
Fluid flow through porous media: Darcy's Law	6.6.4	Design of sand filters for water treatment
Fluoride options: generation of possible consequences	4.7.3	Enables decision making

(*Continued*)

Table 5.1 (*Continued*)

Creative/innovative system, facility, structure, product, process, service, or approach	Section(s) in book where described	A major benefit
Gas filler door and cap combination	4.12.4	Easier to use
Golden Gate Bridge	6.4.1	Iconic structure
Grass seed in cattle feed	4.12.1	Reseeds range land
Gravitation: universal/mutual theory of	4.3.3	Improves understanding of the natural world
Home battery: Tesla Powerwall	6.8.3	Provides energy when not available or too expensive
Integrated circuit	6.3.5	Simplification
Masking tape	6.6.2	More effective painting
Micropiles	4.12.4	Suitable for use in restrictive situations
Microwave oven	3.6.4	Faster food preparation
Meeting agenda: good news item	7.3.4	Increases awareness of organizational activities
Mental and physical activity studies	2.15.2, 2.16.3	Longer life and less dementia risk
Motion Theory: Newton's laws	4.3.3, 6.3.2	Improves understanding of physics
Music in retail sales	7.5.1	Influences types of purchases
Office layouts	7.8.5	Enhances collaboration
Opera house: Sydney, Australia	7.2.5	Iconic structure
Oxygen produced by photosynthesis	3.6.3	Improves understanding of the natural world
Panama Canal	4.12.5	Reduces shipping time
Penicillin	3.6.5	Widely used antibiotic
Peristaltic pump	7.2.5	Prevents contamination of pumped liquids
Personal computer features and functions	6.7.1	Global impact on personal effectiveness
Phonograph	4.3.4	Entertainment
Pipeline: use of aqua ammonia	4.12.6	Transport different liquid petroleum products serially in the same pipeline
Pond problem: definition of	4.7.1	Enable search for solution
Printing press with reusable type	1.3.2, 4.3.2	Historic global communication impact
Props in presentations	9.3	Holds attention and communicates
Prostheses: neuro	8.4	Enhances tactile, visual, and auditory functions
Q Drum	6.2.1	Improves health in developing countries
Railroad station columns: Lisbon, Portugal	7.2.3	Unusual palm tree forest design
Reward for using public trash containers	4.12.1	Solves refuse problem in public areas
Rover on Mars	8.2	Exploration
Skyscraper: Malmo, Sweden	7.2.3	Unique twisted spine shape
Smartphone	5.6.2	Combines many functions, including voice, photographs, video, and web features capabilities
Soapboxes: detecting empty ones	7.9.3	Cost-effective solution
Split-brain studies	2.15.1	Understanding of left and right hemisphere capabilities
Spoon and fork combination (spork)	4.12.4	Reduces cost
Storm water facility failure assessment	4.5.1	Basis for resolving issue
Storm water management facility	8.7	Multipurpose: recreation and flood control

Table 5.1 (*Continued*)

Creative/innovative system, facility, structure, product, process, service, or approach	Section(s) in book where described	A major benefit
Storm water runoff formulation: Rational Formula	4.3.4	Design of urban storm water runoff systems
Street storage of storm water	4.12.3	Reduces cost of public works
Structural elements that are honey combed	7.2.5	High strength-to-weight ratio
Suspension bridge: first major one and theory	4.3.4	Widely applicable theory
Taco Bell restaurant : 48 hr. construction	4.12.2	Cost savings on subsequent construction
Telephone	4.3.3	Enhances personal communication
Television	6.3.3	Transmit images
Television network	6.3.3	Massive information sharing
Theory of Inventive Problem Solving	7.9	Leverage the creative/innovative approaches of others
Train: high speed	6.6.3	Noise reduction
Utility office operations assessment	4.10.2	Improves effectiveness and efficiency
University engineering department: ideas	4.7.3	Provides stimulating ideas
Vacuum cleaner: Dyson bagless	6.8.3	Improves carpet cleaning
Velcro	1.3.2	Many useful fastener applications
Visual art techniques	6.3.2	More realistic portrayals of subjects
Vulcanization	3.6.2	Rubber for many uses
Wave theory	6.3.2	Improves understanding of physics
Weed eater	6.6.1	Easier lawn maintenance
Wetlands: floating	7.2.4	Enhances surface water quality
Xerography	6.8.2	Faster copying

temporary roadblocks to be moved aside or barriers to climb over. Accordingly, as suggested by Figure 5.1, this chapter's purpose is to identify seven obstacles or roadblocks to creativity and innovation and then offer suggestions as to how you and your group or team can deal with them for the benefit of yourself, your organization, and society.

5.1.2 Obstacles from within You

The preceding discussion of obstacles to your creative and innovative urges assumes that the obstacles come from outside you. That is, your inclination to explore different approaches to resolving an IPO is hampered by your team, your academic department, your employer, your boss, or some other external entity.

Please recognize that, in contrast to these external impediments, some obstacles will come from within you. You may initially be inclined to take a creative or innovative approach, but when specific opportunities arise you might decide not to do so for any number of reasons, including one or more of the obstacles that are about to be discussed, perhaps fueled by your brain's negativity bias(as explained in Section 2.12).

For example, a professor invites you to take the lead on a small, well-defined part of her research project, but you decline because you fear you lack the innovation ability to contribute to a research effort. You think about taking a

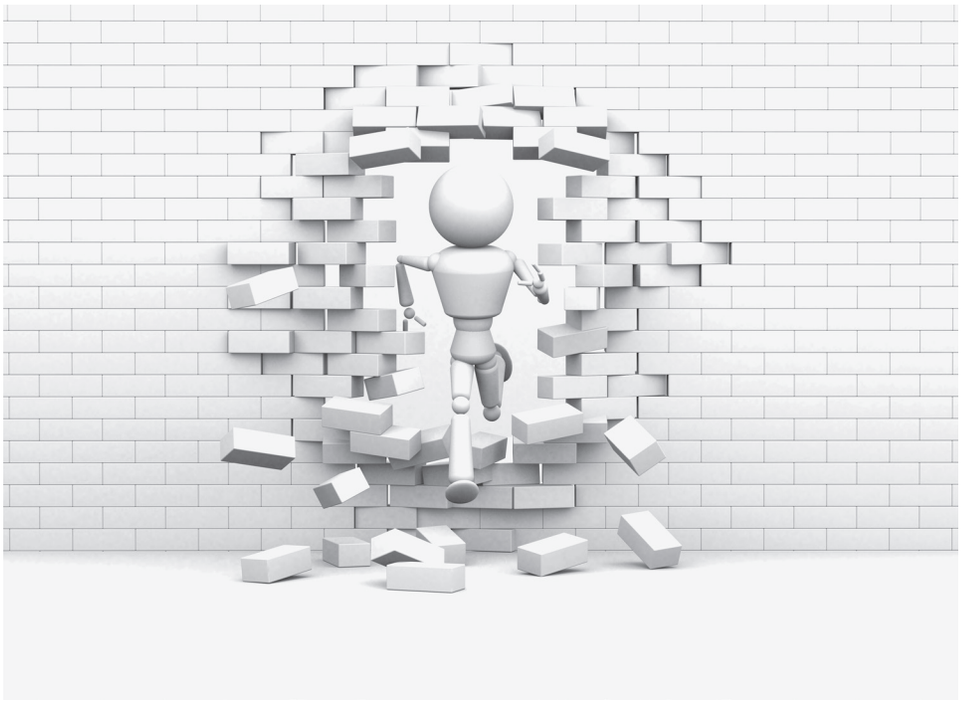

Figure 5.1
This chapter identifies possible obstacles to your and your team's creative and innovative intentions and offers ideas on how to overcome them.
(Suphakit73/Fotolia)

painting class while at the university, but decide not to because you have been told that you are not creative. In your first engineering position, your department head asks for a volunteer to help draft a social media policy for the organization, and you hesitate to get involved because you have never helped develop a policy and fear you might fail. As noted by Pogo, the amiable and philosophical comic strip opossum, "We have met the enemy and he is us."

Hopefully, the following discussion of obstacles to creativity and innovation will help you and your teams recognize the external variety of obstacles, see most of them as temporary roadblocks, and move past them. This discussion should also help you see and deal with the "enemy within."

5.2 FEAR OF FAILURE

We begin our discussion of creativity and innovation obstacles with fear of failure (especially catastrophic failure) of that which is planned, designed, constructed, or manufactured. Engineers, especially in some disciplines such as civil engineering, have traditionally and understandably been risk averse because of the possible disastrous consequences of failure of large, complex, one-of-a-kind structures, facilities, and systems, like that illustrated in Figure 5.2

5.2.1 Concern with Public Safety, Health, Welfare, and Costs

Moving away from the tried-and-true approach and toward an innovative and experimental mode raises the specter of violating the engineer's highest responsibility: protecting the safety, health, and welfare of the public. This paramount responsibility is explicitly prescribed in the ethics codes of essentially all engineering disciplines. For examples, refer to the codes of the American Council of Engineering Companies (ACEC), the American Institute of Chemical Engineers (AIChE), the American Society of Civil Engineers (ASCE), the American Society of Mechanical Engineers

Figure 5.2
Engineers strive to avoid failures of large, complex, one-of-a-kind structures, facilities, and systems.
(Baloncici/Shutterstock)

(ASME), the Institute of Electrical and Electronic Engineers (IEEE), the National Society of Professional Engineers (NSPE), and other engineering societies.

In addition to one-of-a-kind entities, fear of failure also applies to many-of-a-kind products. "When a product engineer at a car company considers making a change to a design or proposing a new approach to an engineering problem, the potential financial impact of being wrong is huge if this results in a costly recall of thousands or hundreds of thousands of cars," according to electrical engineer Fruechte (2014), who worked in automobile research and development. He goes on to explain, "One of the fears is not considering the unintended consequences when taking a new path."

Besides technical failures, we can also have failures in nontechnical areas. As engineers, we may fear situations and events such as exceeding our project budget, missing project and other deadlines, making poor presentations to our peers, and rejections of our proposals. Understandably, fear of failure in nontechnical and technical activities can squelch the inclination to try a new approach; we might not pursue a creative or innovative idea because we fear failure. Perhaps we are controlled by negativity bias (Section 2.12), or we're trapped by the *FUD factor*: fear, uncertainty, and doubt (Carlson and Wilmot 2006).

5.2.2 Remedies

Even when we carefully use traditional, tried-and-true design methods, we risk failure. As explained by Henry Petroski in his book *To Engineer is Human* (1985), using a hypothesis framework, "The process of engineering design may be considered a succession of hypotheses that such and such an arrangement of parts will perform a desired function without fail." He goes on to say the we can never be absolutely certain about the "fail-proofness" of any of our designs because we cannot imagine all the things that could go wrong. In other words, we can never enjoy zero risk of failure in our technical and nontechnical activities.

The risk of failure may seem small with traditional approaches, but it would seem to be greater with creative and innovative approaches. However, consider the following:

- Maybe some of the failures and shortcomings that occur with tried-and-true engineering approaches would be eliminated if we employed creativity and innovation to develop improved analysis, planning, and design methods. Early in my career, I benefited from the then recently developed digital computer watershed hydrologic–hydraulic models, which helped me, my teams, and those we served make better infrastructure and environmental decisions. In return, I wrote and spoke about our applications of the models with the hope of encouraging others to use and benefit from them. The models reduced the likelihood that recommended facilities would fail.
- We routinely benefit from the creative/innovative work of our predecessors. This implies that we in turn have an obligation to advance the engineering profession's approaches and tools for the benefit of our successors and those they serve. Such advances will require creativity and innovation. English scientist and philosopher Bacon, described the obligation this way: "I hold every man a debtor to his profession; from that which a man has course to seek countenance and profit, so ought they of duty to endeavor themselves, by way of amends, to be a help and ornament there unto." In other words, we take much from our profession, so let's give something back—and if it is creative/innovative, all the better.
- The risks associated with creative and innovative ideas and methods can be minimized by cautious measures such as research, testing, pilot studies, prototyping, and phasing. Section 4.12.3 illustrates What If by describing an innovative project in which storm water was intentionally temporarily stored on streets throughout an 8.1 square mile community in order to prevent surcharging of combined sewers and the related widespread basement flooding. Because this was the first major application of street storage, the project presented many risks such as failure to control flooding, pavement deterioration, icing of streets, and interference with movement of emergency vehicles. That risk was defined and reduced by means such as studying smaller-scale efforts elsewhere, fabricating and experimenting with various flow control devices, driving vehicles over trial low water control structures, conducting pilot studies in small drainage areas, and phasing the eventual community-wide construction (Walesh 2000, Walesh and Carr 1999).

5.3 BELIEF THAT CREATIVITY AND INNOVATION ARE NATURAL AND NOT LEARNED

You may hear expressions like "she was born creative" and "he is naturally innovative." As illustrated in Figure 5.3, this suggests that a person's creativity and innovation potential is determined at birth and that this wonderful ability is essentially a matter of nature, not nurture. This line of thinking can be an obstacle to you realizing your potential to think in entirely new ways.

5.3.1 Nurture: The Primary Determinant of a Person's Creative/Innovative Ability

Is it true that creativity and innovation potential is determined essentially by nature? Not according to many researchers and authors. For example, academic researchers Dyer and Gregersen (2011) state, "Our study of over 5000 entrepreneurs and executives shows . . . [that] almost anyone who consistently makes the effort to

Figure 5.3
Some believe that a person's creativity and innovation potential is mostly a matter of nature, not nurture.
(Svetlana Fedoseeva/Fotolia)

think different can think different." They go on to suggest a few methods to encourage creative and innovative thinking, consistent with the use of the methods presented in this book.

"Although creativity has long been considered a gift of a select minority, psychologists are now revealing its seeds in mental processes, such as decision making, language, and memory that all of us possess," according to researcher Chrysikou (2012). She goes on to say that studies reveal that we can be more creative and innovative if we use "strategies that encourage unconscious thought processes." Many of the methods in Chapters 4 and 7 engage the subconscious mind.

Altshuller (1996), the Russian developer of the Theory of Inventive Problem Solving (TRIZ), which is described Section 7.9, said "The theory of inventing can be taught at any age." He indicated that his creativity and innovation tools were used effectively by children in the fifth and sixth grades, and a major theme in his book is that anyone can be inventive if they are provided with some tools.

Based on the preceding information and my presentation and breakout experiences, I reject the idea that birth defines one's creativity and innovation potential. On the contrary, your ability to think in entirely new ways and directions is determined mostly by nurture and only secondarily by nature. That nurture element should include gaining an understanding of brain basics, as presented in Chapter 2, and the use of whole-brain tools, as discussed in Chapters 4 and 7.

5.3.2 Remedies

Most likely, you or those you work or interact with discount the possibility of being innovative and creative because you or they have heard or believe that a person is either born that way or isn't. I urge you and them to do at least two things, lest you miss some thrilling and satisfying experiences.

First, study at least some of the sources just cited that support the idea that creativity and innovation ability can be learned, that is, it is determined by nurture, not nature. Second, individually or as a group approach, take on some challenging IPOs by drawing on the Chapter 2 brain primer and applying one or more of the whole-brain methods described in Chapters 4 and 7 of this text. Stimulated by those methods, your innate creative and innovative capabilities will become apparent.

5.4 NEGATIVE RESULTS OF THE LEFT-BRAIN EMPHASIS IN FORMAL EDUCATION

Another possible obstacle to creativity and innovation is the left-brain emphasis in US formal education. Artist and author Edwards (1999) wrote the following about the US K–12 and beyond educational system: "Most of our educational system has

been designed to cultivate the verbal, rational, on-time, left hemisphere, while half of the brain of every student is virtually neglected." She further notes that although there are a few art, shop, and creative writing K–12 classes, finding courses about imagination, visualization, perception, creativity, intuition, and inventiveness is unlikely.

Others criticize what they see as the tendency of K–12 education to discourage student inquiry and creativity/innovation by focusing students on finding and giving what the teacher wants. Educator and cultural critic Postman suggests that when naturally inquisitive children enter K–12 education, they can be thought of as question marks, but by the time they leave, they look like periods. They spend too much time thinking about what the teacher is thinking and wants, and too little time thinking about what they are thinking and would like to know. The stress is on the teacher's head rather than their own (von Oech 1990). Test the validity of these allegations by thinking about your K–12 experience.

5.4.1 Engineering Education

Might the preceding discussion of K–12 education also generally characterize engineering education? I think so. For example, in late 2014 and early 2015, I studied the Civil Engineering Body of Knowledge (CEBOK), the aspirational "necessary depth and breadth of knowledge, skills, and attitudes required of an individual entering the practice of civil engineering at the professional level [licensure as a professional engineer] in the 21st century" (American Society of Civil Engineers 2008). Knowledge is what you know, skill is what you are able to do with what you know, and attitude is how you respond to various situations.

I took on this project because the CEBOK was about to be reviewed for a possible third edition or at least some revisions. My purpose was to determine if creativity and innovation were present in the CEBOK and to learn the extent to which creativity and innovation were part of the formal education and prelicensure experience of civil engineers.

My study (Walesh 2015a) concluded that the current CEBOK, even though it's forward-looking in many ways, gives minimal attention to creativity/innovation. The investigation, informed by education and practice experience, also led me to conclude that creativity and innovation are not widely taught and learned in CE bachelor programs and that creativity/innovation fundamentals are not acquired during prelicensure experience. I conclude by recommending that creativity and innovation be integrated into the next version of the CEBOK and offer ideas on how this could be done.

I also studied (Walesh 2015b) the aspirational Engineering Body of Knowledge (EBOK), which is defined similarly to the CEBOK but applies to essentially all engineering disciplines and was published by the National Society of Professional Engineers (National Society of Professional Engineers 2013). My analysis indicates that creativity and innovation receive minimal attention in the EBOK.

We could do much more to prepare US engineers, regardless of their disciplines, to be creative and innovative for their own sake and for the benefit of society. One tactic is to include creativity/innovation in the next versions of the CEBOK, EBOK, and other engineering bodies of knowledge or similar documents. Inclusion in these aspirational documents will encourage more explicit treatment of creativity/innovation in the formal education and prelicensure experience of engineers.

Engineering educators Goldberg and Somerville reach a similar conclusion, writing, "It is surprising how little emphasis is placed on imagination, creativity, and design within the standard engineering curriculum today" (Goldberg and

Somerville 2014). After a cursory review of courses required in US engineering schools, they concluded that only a small fraction include the word *design* and address creativity. For the design courses, they observed that many "include very little discussion of creativity and the thought processes that underlie it," which they consider remarkable, "given the importance of this mode of thinking to the fundamental purpose of engineering."

5.4.2 You May Be an Exception

Some of the preceding information may not apply to you, in that you may be deeply involved in creative/innovative whole-brain activities, such as art and music. While working in university education, I collected and analyzed campus data showing that although engineers made up 10 percent of the student body, they comprised more than 20 percent of the campus musical groups and more than 20 percent of the campus leadership positions. Colleagues at other universities have shared similar observations. To some extent, you and other engineering students may have offset the left-brain emphasis of the formal education system. Another possibility is that you may be fortunate to be in an academic program committed to or experimenting with a whole-brain approach, possibly indicated by the use of this text.

5.4.3 Caveat

Lest there be any misunderstanding, nothing in this text is intended to detract from the value of left-brain capabilities. The typical student or practitioner engineer's critical thinking knowledge and skill, which is largely left-brained, is a powerful and often not fully recognized and appreciated force. Critical thinking can be generally viewed as an objective, self-disciplined, and rational thinking process. Critical thinking, which you probably already use when presented with a technical challenge, means defining the depth and breadth of the challenge, obtaining data, asking questions, invoking applicable principles, applying deductive and inductive reasoning, developing hypotheses, drawing conclusions, generating and evaluating options, and selecting and implementing a course of action.

Left-brain capabilities are powerful, and with continued development they will serve you well throughout your career. This text urges you—and shows you how—to celebrate your left-brain capabilities and complement them with right-brain capabilities and interaction between your conscious and subconscious minds so that you acquire whole-brain capabilities. You and your teams and organizations, while in school and beyond, are more likely to be more successful and achieve greater significance if you frequently engage in whole-brain thinking.

5.4.4 Remedies

If you believe that your formal education up to now has been too light on courses and topics that tend to engage the right side of your brain, you can begin to take some remedial actions. For example, enroll in a visual or performing arts class at your college or university; you may experience an awakening of parts of you that you did not know existed. In a similar vein, learn how to play an instrument; sign up for an overseas study, travel, or service experience; or research a right brain-themed topic that interests you.

As you move into professional practice, be aware of the role of creativity/innovation in K–12 education and in engineering education. Consider becoming an advocate for a whole-brain approach and exert influence in engineering education and practice as opportunities arise.

PERSONAL: ART AND MORE APPRECIATION OF MY RIGHT HEMISPHERE

Several years ago, after an over five-decade lapse that began after the third grade, I returned on a whim to art by taking a graphite pencil drawing class, loving it, going to classes, and creating a variety of drawings. I soon moved to colored pencils and discovered that I would draw in graphite or colored pencil, with some acrylic accents, for two or more hours while being oblivious to the passage of time. In returning to art, I initially envisioned no connection to engineering education or practice. This was simply a pleasant diversion. However, in addition to creating pencil drawings that I never envisioned (see Figure 5.4), this return to art had another creative/innovative effect.

As a result of drawing, thinking about drawing, talking to my art instructors and other students, and doing some reading, I began to see possible connections between visual arts and improving engineering education and (ultimately) practice. I was referred to and read Edward's book *Drawing on the Right Side of the Brain* (1999). That led to more research, including on recent neurological discoveries; interacting with colleagues; writing articles; presenting papers; conducting workshops; and writing this book. One thing can lead to another for you, as it did for me—but you have to start the process and be open to possibilities.

In summary, my entry into art on a whim enabled me to draw well, learn about the human brain, and use that knowledge to help engineers be even more creative and innovative. If you venture outside of your comfort zone, you are very likely to have similar eye-opening, whole-brain, and satisfying experiences. You only go around once, as they say, so make it a great trip.

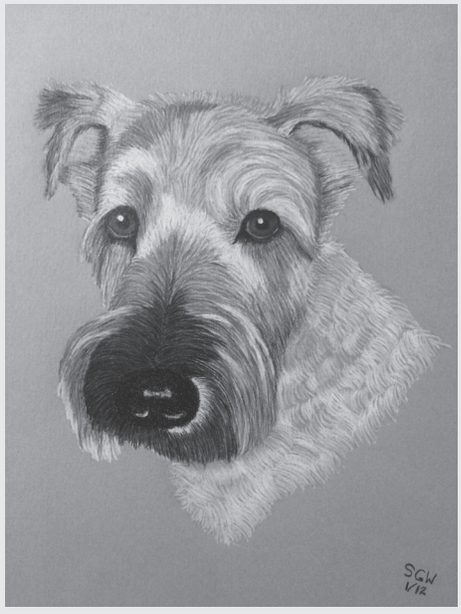

Figure 5.4
Colored pencil drawing of Ize, the author's dog.
(Stuart Walesh)

5.5 RELUCTANCE TO CHANGE

Another possible obstacle to creativity and innovation is simply reluctance to change, or even fear of change. We have a word for that: *misoneism*, which means "a hatred, fear, or intolerance of innovation or change" (Merriam-Webster 2014a).

5.5.1 Why We Resist Change

Why do many of us resist change? The possibility of change causes each of us to compare the way things are to the way things could be. We contrast the familiar and comfortable with the unfamiliar and uncomfortable. I believe that most of us can see and weigh the pros and cons of a proposed change at the cognitive level, especially if thoughtfully presented. However, even if the pros clearly outweigh the cons at the cognitive level, we fear how we are going to get from here to there at the emotional level.

As suggested by Figure 5.5, we recognize the current situation, understand the proposed change, realize it would be better, but tend to be intimidated by that unknown chasm between where we are and where we could be. The trip is scary; therefore, when faced with change, we often revert to fear and other emotions, not reason (Walesh 2012b).

Consider another change-resistance factor. We are characterizing creativity/innovation as requiring a whole-brain approach. To some, this may imply that up to now, they have been using a half-brain approach. By being receptive to a whole-brain approach, might they be refuting what they've done for a long time? Might fear of embarrassment be an obstacle? Do we risk losing face?

Kaplan (2011) offers reasons companies fail at self-reinvention—that is, thinking about new business models, such as (in keeping with this book) a model that expects creativity and innovation. He says: "The most obvious reason companies fail at business model innovation is because CEOs and their senior leadership teams don't want to explore new business models." He goes on to explain that CEOs like the current models and expect the organization's personnel to improve their performance. In other words, let's not change; instead, let's try harder. As a result, according to McArdle (2012), "most companies wait far too long to even recognize

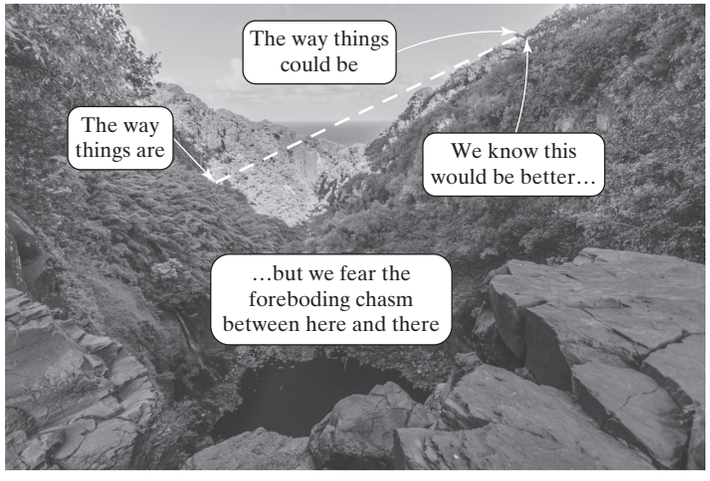

Figure 5.5
Although we may understand that a suggested major change would be a significant improvement, we sometimes resist because of the foreboding chasm between here and there.
(Don Landwehrle/Fotolia)

that they have a problem. . . . Even a dysfunctional culture, once well established, is astonishingly efficient at reproducing itself." For example, Netflix destroyed Blockbuster, digital cameras took Kodak down, and some engineering firms disappeared when they were purchased and disassembled.

VIEWS OF OTHERS: CHANGE IS HARD

Recognizing the frequent initial knee-jerk resistance to change, like that which may result from a creativity/innovation initiative, economist Galbraith said, "Faced with the choice between changing one's mind and proving that there is no need to do so, almost everybody gets busy on the proof." Machiavelli, the Italian politician and writer, explained opposition to change as follows: "There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiators have the enmity of all who would profit by the preservation of the old institutions and merely lukewarm defenders in those who would gain by the new one" (Machiavelli 1980). Note, in particular, his mention of the initial "enmity" of many who oppose change contrasted with the "merely lukewarm defenders" of change.

The change associated with your creative/innovative proposal is likely to be vigorously opposed by some while being only casually supported by others. Kettering, engineer and inventor, warned, "If you want to kill any idea in the world, get a committee working on it." In a more positive vein, "All truth goes through three stages," according to German philosopher Schopenhauer. "First it is ridiculed, then it is violently opposed, finally it is accepted as self-evident." Creativity and innovation means change, and change will be opposed by many. Be prepared.

People offer many reasons to resist change, but might a major change now, either personally or organizationally, be better than major regret later? "One of the saddest experiences which can come to a human being," according to Burrows, "is to awaken gray-haired and wrinkled, near the close of an unproductive career, to the fact that all through the years he has been using a small part of himself."

5.5.2 Change Resistance in the Political Environment

Some engineers, especially civil engineers because they often work with elected and appointed public officials, will encounter politically driven resistance to change when they present their creative/innovative ideas. For example, the idea may have merit on all fronts except for timing.

Consider this scenario. You are the city engineer, a position you have held for several years, and the mayor is beginning the second year of her first four-year term. She is cautious, a quick learner, doing well, and already planning to run for a second term.

You and your staff have been working on an innovative energy idea that would provide long-term financial benefits to the city. Your team's idea is to establish a citywide system of solar collectors that would meet most municipal electric energy needs and that would feed energy into the regional network at times of low city energy needs, for which the city would receive monetary credit. Panels would be placed on city-owned buildings and facilities, such as city hall, schools, parking

structures and shelters, bus and train stations, utility poles, and public works buildings. Preliminary engineering studies indicate that the system is technically feasible.

Your group also completed a preliminary long-term economic analysis in which you projected annual revenue and costs for the next twenty years. Assuming the project's detailed engineering begins next year and construction and installation get underway in few years, the analysis indicates economic success. That is, the large design and construction/installation costs that would be incurred in the first three years of the project would be offset in the project's first eight years, after which annual energy cost savings plus credits from the local power company would exceed annual operation and maintenance costs. Furthermore, the city could apply for some state and federal grant programs ending in three years to fund design and some capital costs. Because this would be the first project of this type in your state, both state and federal funding are very promising. This is a great project from a technical, economic, and financial perspective.

You meet with the mayor, enthusiastically describe the project, and are surprised at her negative response. She says the project seems risky (you did your homework and believe otherwise), requires too big an investment (yes, but would generate a much bigger return), and "the time is just not right" (state and federal funding are very likely if the city moves quickly). She asks you to abandon the effort and to keep the work that you and your staff performed confidential. You quickly conclude that politics, mainly her reelection, is her principal concern.

These kinds of politically motivated decisions occur often; if you choose to be in the public arena, you will need to deal with them, possibly in a creative/innovative manner. The following are some options for responding to the mayor's position:

- Stress the positive attention that the project would bring to the city.
- Suggest verification of your team's analysis by a consulting firm.
- Convene a public meeting at which the mayor could present *her* idea and gauge the response, especially with respect to timing.
- Conduct a modest pilot project to demonstrate the technology and keep the idea alive.
- Put the innovative idea on the back burner and wait for a favorable political climate.

PERSONAL: POLITICS AND YOU

I do not want to leave the impression that the political process is objectionable. I like this politics definition: "The art and science concerned with guiding or influencing governmental policy" (Merriam-Webster, 2014b). The definition does not attach an ethical or unethical, legal or illegal, or positive or negative quality to the political process. Recognize that politics, like any type of interaction among individuals, can be anywhere on the ethics, legal, or positive/negative scales. In any situation, we the participants place the process on those spectrums by our words and actions.

My hope is that you will participate in politics—that is, "guiding or influencing" public policy—and that you will strive to do it creatively and innovatively. Attend public meetings and share your views, serve on and lead ad hoc committees formed by public bodies, vote, assist candidates running for elected office, and be a candidate. Given your intelligence and knowledge, especially of scientific and technical matters, you have much to contribute.

My views aside, the engineering profession encourages you to positively participate in the political process. For example, the EBOK (National Society of Professional Engineers 2013) defines knowledge, skills, and attitudes appropriate to enter practice as a professional engineer. One of the capabilities in the EBOK is "Public Policy and Engineering," which urges you to understand public policy and consider influencing it. If you seek guidance for a particular political situation, refer to one or more of the engineering codes of ethics referenced in Section 5.2.1.

5.5.3 Remedies

When your creative/innovative approach to an IPO begins to gather attention and, more specifically, resistance, consider responding to and managing the process using the cascading awareness-understanding-commitment-action process shown in Figure 5.6. The process cascades in that it flows from the top to the bottom, the number of participants typically becoming markedly smaller as the process proceeds. However, even so, the number of individuals remaining at the last level (*action*) is often adequate to effect change.

As illustrated, on becoming aware of a possible change, many of us react in a mostly emotional knee-jerk fashion. You should anticipate and gracefully and patiently tolerate knee-jerk reactions. Simply ask for understanding of what is being proposed and the reasons for it. Some knee-jerkers will show you that courtesy and express openness, and on understanding, a portion of them will commit. Finally, for some, commitment will lead to the action needed to advance the creative/innovative effort: They will join you. For a comprehensive discussion of change, see Chapter 15, "The Future and You," in my book *Engineering Your Future* (Walesh 2012c).

5.6 LOSS OF BILLABLE TIME AND OTHER ORGANIZATIONAL IMPEDIMENTS

For engineers working in professional services (such as a consulting engineering firm), maintaining billable time targets is critical. *Billable time* is the time engineers work that can be billed to clients to generate income, in contrast with those hours that are not billable. As the percent of billable time drops, so does profit (Walesh 2012a). Therefore, losing billable hours is a fifth possible obstacle to creativity and innovation. If you are going to enter a professional services firm, be aware of the need to meet billable time criteria and the related creativity/innovation obstacle. The government, academic, or volunteer sector parallel obstacle might be, "time for creativity and innovation is not in our budget; we have more important work to do."

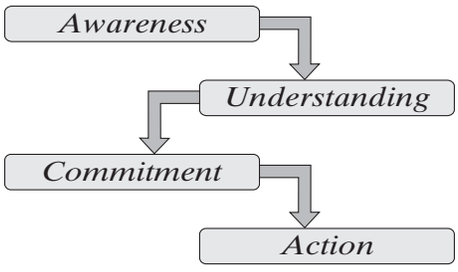

Figure 5.6
As the creator or innovator, you should anticipate and patiently work through the cascading awareness-understanding-commitment-action process.

More specifically, an engineering consulting firm could easily experience the following two short-term billable time (and profit) hits if it tries to be more creative and innovative:

- Nonbillable time incurred by individuals working on creativity/innovation tasks not billable to clients
- Time and other resources needed to implement a team's promising idea

5.6.1 Business Realities

I empathize with managers in engineering firms, as a former department manager in one. They need immediate results in terms of time utilization and other metrics, and *immediate* typically means *this week* or *this month*. "So even though managers know that innovation is necessary," according to consultant Ashkenas (2012), "most do not have the patience [or flexibility] to wait [months or] years for results. Consequently, they say innovation is important, but they don't back it up with time or resources." His comments remind us that even when billable time is not a major productivity metric, the uncertainty of the results of a proposed creative/innovative effort will be an obstacle to initiating it.

When any of us learn to think differently as individuals or teams, we act differently; this may incur short-term costs—but, and this is a big *but*, the long-term return on that investment of occasional billable time hits and other disruptions could be tremendously positive. Clearly, we need both short-term thinking, like billable time tracking, and long-term activities, like strategic planning. "But the safety of the short term is an illusion," warns innovation expert Kao (2007). "The hot winds of disruption swirl all around us, whether they be in the form of new competitors, business models, technologies, consumer preferences, or geopolitical factors."

Billable time and other considerations aside, some managers may oppose creativity and innovation to protect their turf. Ashkenas argues that although a particular innovative idea might give the manager's firm an edge over competing firms, it may also adversely affect the manager's department or other unit vis-à-vis other departments or entities. "In other words, while managers might want to disrupt their competitors, they are less comfortable disrupting themselves."

A final manager thought: The admirable slow, continuous improvement philosophy, which thrives in a few business, government, academic, and volunteer organizations or portions of them, can be an impediment to typically disruptive creativity/innovation initiatives. Therefore, "managers who have grown up in a continuous improvement culture may be uncomfortable with change that doesn't happen step-by-step" (Ashkenas 2012). This is not meant to be critical of continuous improvement but to suggest that managing it and creativity/innovation side by side can be a challenge.

5.6.2 Remedies

Recognize that the return on the resources invested in creative/innovative initiatives may be tremendous. Think back to the year 2000: What tools and techniques that you and other engineering students and practitioners use today existed then? The following did not: iPod, iTunes, iPhone, iPad, readily available GPS, the Google search engine, building information modeling (BIM), 3-D printing, and social media (Isaacson 2011).

Perhaps the most significant electronic advancement in the past decade is the smartphone, which gained popularity with the advancements of the iPhone, introduced by Apple in 2007. It "turned mobile phones into music, photography, video,

email, and web devices" (Isaacson 2011). It also spawned numerous competitors, such as Google's Android phones and Microsoft's Windows phones, and begat thousands of application developers. The smartphone changed how people relate to each other (e.g., texting versus email or the telephone) and how people acquire information (Fruechte 2014).

What might be the equivalent successful, creative, and innovative products or services in your business, government, academic institution, or other organization? Do you really want to forgo finding out? If not, you and your organization need to take the long view, need to invest in the quality of people you assemble, the leaders you identify, and the creative/innovative ideas you encourage. Given the smart people typically found in engineering-oriented organizations, you never know what they might come up with.

For some practices that could help to strengthen an existing innovation culture or develop one from scratch, refer to Section 7.8. These are ways to offset impediments to creativity/innovation in all types of organizations, including on-campus student organizations. I am not suggesting that your organization do all of them. Instead, think of the list as a smorgasbord of ideas that you could choose from or that might stimulate other approaches.

5.7 MISCONCEPTIONS ABOUT ARTISTS

Another possible obstacle to having some engineering students and practitioners embrace creativity and innovation initiatives is that mentioning *creativity* may engender a negative reaction about alleged "creative" types. As stated by author Miles (1997), creativity's "association with a marginalized artistic life-style devalues its worth." This suggests that some of us think that creativity is for free-spirited, brush-wielding, devil-may-care "artistic" types with lots of time on their hands. In stark contrast, we engineers have real, practical work to do!

Or, we may have observed that a few of the highly creative people we have known or are aware of are somewhat eccentric. The famous engineer Tesla developed the first practical commercial use of alternating current motors, generators, and transmission lines. His eccentricities included loving pigeons and the dark, and fearing germs and round objects. Kamen, inventor of the Segway scooter, never takes vacations, and Einstein "picked up cigarette butts off the street to get tobacco for his pipe" (Pickover 1998). Researcher Carson (2011) says, "The incidence of strange behavior by highly creative individuals seems too extensive to be the result of mere coincidence." According to psychology professor Simonton (2012), "top performers are not a very normal bunch."

5.7.1 Free the Artist Within

Recall the *free to be foolish* discussion (Section 3.2.4), which argues that the path to creatively and innovatively resolving an IPO requires the freedom to be foolish, daring, unreasonable, unconventional, and eccentric and to at least temporarily think counter to reason, authority, and common sense. Although it does not suggest that we need to be inherently eccentric, that section suggests that being temporarily so is likely to be fruitful.

Carson goes on to share the hypothesis that "reduced cognitive filtering could explain the tendency of highly creative people to focus intensely on their inner world at the expense of social and even self-care needs." She explains that "reduced cognitive filtering" means that some individuals are more likely to benefit from the cognitive processing that "goes on in our brains behind the scenes," in their

subconscious minds. This can lead to exceptional insights that flow from the subconscious into the conscious mind. *Bottom line:* Highly creative individuals may be somewhat eccentric; let's welcome them and their contributions so that all may benefit: us, them, our organizations, and, most importantly, those we serve.

Consider another perspective. We may narrowly associate creativity with visual or performing arts—rather than, much more broadly, as a way of thinking. I suspect that many of you can envision an artist coming to his or her studio in the morning and saying, "What painting or sculpture will I create or start today?" In contrast, how many of us, when we come to school or work, will say, "What concept, idea, process, or thing will I create or start today?" Do you have a creative/innovative mind-set? McCuen (2012), a civil engineering professor, offers this thought: "The attitude that creative thinking is fun, but unnecessary to solve today's problems, needs to be replaced with the attitude that creative thinking is an essential problem-solving tool." What are you going to create today?

PERSONAL: ENGINEERS AND ARTISTS HAVE MUCH IN COMMON

As a professional engineer and an amateur artist, I understand how some very pragmatic engineers may not see or feel a connection to artists or to creativity. However, engineers and artists have much in common:

- We both study and apply fundamentals. In my first graphite pencil drawing class, the instructor explained that a successful drawing required three basics that proved to be widely applicable. First, the principal subject should not be in the center. Second, if I am drawing a duck, it should look like a duck; for me to do that, I had to really see, not just look at, a duck. Third, use various intensities of graphite to achieve a three-dimensional effect on a two-dimensional medium. In Static Mechanics, one of my first engineering classes, we also learned widely applicable fundamentals.
- We both should be very careful observers; we can't just look, we must see. In art, failing to see means missing and failing to portray the richness of the subject. In engineering, failing to see means misdiagnosing the IPO.
- We both produce one-of-a-kind results.
- We both can appreciate the historic and linguistic connections between engineering and creativity (Section 1.5).

5.7.2 Remedies

If you are inclined to resist creative/innovative urges or efforts (yours or others) because they suggest frivolity, then visit an art gallery or museum and see, not just look at, the displayed works. Attend a concert and really listen. Ask artists and musicians what they view as the fundamentals that enable them to do their work, and think about the fundamentals that enable you to do yours. You may find, as I have, that most artists rely on fundamentals and embrace a whole-brain approach.

Perhaps you are uncomfortable with your eccentricities or those of others. Look for the positives. Be guided by essayist and poet Thoreau, who wrote: "If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music he hears however measured or far away." We achieve

the desirable Medici Effect (Section 4.6) when we gather a group of individuals, many of whom are marching to different drummers.

5.8 COMPLACENCY

My last potential obstacle to creativity and innovation to discuss is already having achieved success, which may lead to your organization not being compelled to continue to move forward because it will bask in its accomplishments. Recent and current success becomes an impediment to future success. "Even if you are on the right track," according to humorist and social commentator Rogers, "you'll get run over if you just sit there." Cooper (2006) wrote, "Good and great are the enemies of the possible."

5.8.1 The Success Trap

Current success in the absence of creativity and innovation may be an impediment to future success, or even to future existence. Examples of organizations that seem to have slipped into complacency, some of which were noted in Section 5.5.1, include Kodak, Blockbuster, Borders, HP (Ante 2012), and various engineering firms, manufacturing companies, university engineering departments, government units, and other entities that are no longer with us or barely surviving.

Complacency and its negative effects can sneak up on us. A product engineer who led a successful design, one that is doing well in the marketplace, may be reluctant to rock the boat or mess with success. After all, the product is as good as, or maybe better than, the current competition, and he or she has many other matters to deal with. Meanwhile, the competition may be about to launch a new and better product, and the product engineer's organization will be caught flat-footed (Fruechte 2014).

See Sections 7.8.1 and Sections 7.8.2 for an expanded discussion of organizational culture and its tremendous influence; the forces that seek, intentionally or unintentionally, to kill creativity and innovation; the tendency of dysfunctional organizations to perpetuate themselves; and the consequences. The benefits of countering complacency with a culture and physical environment supportive of creativity and innovation and the means to achieve them are presented in Sections 7.8.3 through Sections 7.8.8.

5.8.2 Remedies

Business, government, academic, volunteer, and other entities should celebrate their individual and organizational successes. Reflect on the causative factors and positive lessons learned. Also note failures and the related lessons learned. Then, ask what you will do for an encore. More specifically, individually and collectively ask and answer the following three questions (based, in part, on Carlson and Wilmot 2006):

1. Who do we serve? Every organization serves someone; otherwise it would not exist for long.
2. What is the greatest current or near-future unmet need among those we serve and would like to serve? If we don't know, let's ask them, perhaps using some of the question-asking concepts and methods in Section 4.2.
3. How will we meet that need? Then, get on with applying the concepts and tools in this book to proactively, and hopefully creatively/innovatively, define and meet that need.

Working through the preceding seemingly simple steps won't be easy, in part because of complacency. You and others are likely to encounter one or more of the obstacles described in this chapter. However, whatever pain you and others feel as you seek to define and meet the next needs of those you serve or want to serve, it will be less than the pain caused by a dying business, governmental, academic, volunteer, or other entity.

5.9 POINTS TO PONDER

In summary, you and/or your team may encounter the following obstacles to your creative/innovative efforts:

- Fear of failure
- Belief that creativity and innovation are natural and not learned
- Negative results of the left-brain orientation in formal education
- Reluctance to change
- Loss of billable time and other organizational impediments
- Misconceptions about artists
- Complacency

The preceding discussion of obstacles makes you aware of them and offers some remedies, with the hope that they may be converted to temporary roadblocks that can be moved or circumvented. Motivated by the obstacles discussion, perhaps you can think of other obstacles and remedies to them.

5.10 TWENTY QUESTIONS

Assume that you and perhaps a core group are working on a creative/innovative project. You have identified a challenging IPO facing your team, department, campus organization, or other entity and think you have a fresh way to resolve it. You also realize that the new direction and its inevitable changes are likely to engender opposition for reasons such as some of the obstacles discussed in this chapter, at least initially. You've considered some of the suggested remedies. However, you want to do more. Therefore, you and your team will ask many questions to help thoroughly define the impact of your project so that you can proactively move forward.

As a guide, refer to the twenty questions listed ahead, which are based in part on Maxwell (1993), Russell (2006), and Walesh (2012b). The list is provided to motivate question asking; it is not all inclusive. Quiz yourself and many others about the possible implications of your creative/innovative ideas, and thus begin to address what should be changed, why it should be changed, who would be or thinks they would be affected, and how and when the change might occur.

1. Are you advocating this new approach primarily for the organization's benefit, or are you doing so mainly to elevate/bring attention to yourself?
2. What is the challenging IPO, and how will you communicate it so others understand it?
3. Is your commitment to your creative/innovative solution sufficient to deal with likely prolonged apathy and/or opposition?
4. Is the change compatible with the organization's mission and vision, or do you propose to change the organization's mission and vision?

5. Who will be positively affected by the change, and what are the actual or perceived benefits?
6. Who will be negatively affected by the change, and what are the actual or perceived costs?
7. What are the long-term implications for the organization of not changing, of proceeding in the current mode?
8. Who will not be impacted, positively or negatively, by the contemplated change but is likely to initially think they are stakeholders?
9. What unexpected changes could occur as a result of implementing your creative/innovative solution?
10. Is the contemplated change visionary enough to excite and engage other leaders, or are you aiming too low?
11. Can you confidently identify likely co-leaders and the reasons they will be supportive?
12. How will the core team learn more about the change process, and how will the group be expanded?
13. Who will be the principal opposition—at least initially—and why?
14. What individuals and/or organizations outside of your organization might assist?
15. Can you point to similar or related changes made elsewhere to use as examples and/or learning experiences?
16. What messages and media will comprise your contemplated communication program?
17. What are some of the major milestones and metrics needed to indicate that the desired change is occurring?
18. What are some small successes that will demonstrate commitment and progress?
19. How will you fund, finance, and/or obtain resources for the change effort?
20. Could your creative/innovative idea be applied on a trial or pilot basis, or would the change be irreversible once it begins?

VIEWS OF OTHERS: VALUE OF QUESTIONS

Let's begin with actor Alda, who offers this advice: "I found I wasn't asking good enough questions because I assumed I knew something," suggesting that we should not inflate our understanding of a new situation, at least initially. Ruskin, an English philosopher, provides this guidance: "To be able to ask a question clearly is two-thirds of the way to getting it answered." "The important thing is to not stop questioning," according to Einstein. An African proverb says, "The one who asks questions doesn't lose his way." Finally, Dell, founder of the company of the same name, said that the idea to start his company was driven by him asking why the cost of a computer was five times the cost of the sum of its parts (Dyer, Gregerson, and Christensen 2014). For additional thoughts about asking questions, see Views of Others in Section 4.2.1.

Opportunity is missed by most people because
it is dressed in overalls and looks like work.

—Thomas Edison, inventor

CITED SOURCES

Altshuller, G. 1996. *And Suddenly the Inventor Appeared: TRIZ, the Theory of Inventive Problem Solving*. Translated by Lev Shulyak from the original 1984 Russian version. Worcester, MA: Technical Innovation Center, Inc.

American Society of Civil Engineers. 2008. *Civil Engineering Body of Knowledge for the 21st Century*, 2nd ed. Reston, VA: ASCE.

Ante, S. E. 2012. "Avoiding Innovation's Terrible Toll." *The Wall Street Journal,* January 7–8.

Ashkenas, R. 2012. "Managers Don't Really Want to Innovate." *Harvard Business Review,* May 1.

Carlson, C. R., and W. W. Wilmot. 2006. *Innovation: The Five Disciplines for Creating What Customers Want*. New York: Crown Business.

Carson, S. 2011. "The Unleashed Mind." *Scientific American Mind*, May/June: 22–29.

Chrysikou, E. G. 2012. "Your Creative Brain at Work." *Scientific American Mind*, July/August: 24-31.

Cooper, R. K. 2006. *Get Out of Your Own Way: The 5 Keys to Surpassing Everyone's Expectations*. New York: Crown Business.

Dyer, J. and H. Gregersen. 2011. "Learn How to Think Different(ly)." *Harvard Business Review*, September 24.

Dyer, J. H., H. B. Gregerson, and C. M. Christensen. 2014. "The Innovator's DNA." *Harvard Business Review OnPoint*, Winter: 122–128.

Edwards, B. 1999. *Drawing on the Right Side of the Brain*. New York: Jeremy P. Tarcher/Putnam.

Fruechte, R. 2014. Former director, Electrical and Control Systems Lab, General Motors R& D Center, pers. comm., August 18 and September 16.

Goldberg, D. E., and M. Somerville. 2014. *The Whole New Engineer: The Coming Revolution in Engineering Education*. Douglas, MI: ThreeJoy Associates.

Isaacson, W. 2011. *Steve Jobs*. New York: Simon & Schuster.

Kao, J. 2007. *Innovation Nation: How America Is Losing Its Innovation Edge, Why It Matters, and What We Can Do to Get It Back*. New York: The Free Press.

Kaplan, S. 2011. "Five Reasons Companies Fail at Business Model Innovation." HBR Blog Network, *Harvard Business Review*, October 12.

Machiavelli, N. 1980. *The Prince*. Translated by E. R. P. Vincent. New York: New American Library.

Maxwell, J. C. 1993. *Developing the Leader within You*. Nashville, TN: Nelson Business.

McArdle, M. 2012. "Why Companies Fail." *The Atlantic*, March: 28–32.

McCuen, R. H. 2012. "Creativity: An Important Problem-Solving Tool for Water Resources in 2050." In *Toward a Sustainable Water Future: Visions for 2050*, edited by W. M. Grayman, D. P. Loucks, and L. Saito, 313–321. Reston, VA: ASCE.

Merriam-Webster. 2014a. "Misoneism." Accessed November 15, 2014. http://www.merriam-webster.com/medical/misoneism.

Merriam-Webster. 2014b. "Politics." Accessed November 22, 2014. http://www.merriam-webster.com/dictionary/politics.

Miles, E. 1997. *Tune Your Brain: Using Music to Manage Your Mind, Body, and Mood*. New York: Berkley Books.

National Society of Professional Engineers. 2013. *Engineering Body of Knowledge*. Alexandria, VA: NSPE.

Petroski, H. 1985. *To Engineer Is Human: The Role of Failure in Successful Design*. New York: St. Martin's Press.

Pickover, C. A. 1998. *Strange Brains and Genius.* New York: William Morrow and Company.

Russell, J. 2006. Professor and Chair, Civil and Environmental Engineering Department, University of Wisconsin–Madison, pers. comm., March 13.

Simonton, D. K. 2012. "The Science of Genius." *Scientific American Mind*, November–December: 35–41.

von Oech, R. 1990. *A Whack on the Side of the Head: How You Can Be More Creative.* Stamford, CT: US Games Systems, Inc.

Walesh, S. G., and R. Carr. 1999. "Street Surface Storage for Control of Combined Sewer Surcharge." In *WRPMD '99: Preparing for the 21st Century,* edited by M. E. Wilson. Proceedings of the 26th Annual Water Resources Planning and Management Conference, Tempe, AZ, June 6–9.

Walesh, S. G. 2000. *Street Storage System for Control of Combined Sewer Surcharge*, EPA/600R-00/065. Washington, DC: US Environmental Protection Agency.

Walesh, S. G. 2012a. "Basic Accounting: Tracking the Past and Planning the Future." In *Engineering Your Future: The Professional Practice of Engineering*, 299–327. Hoboken, NJ/Reston, VA: Wiley/ASCE Press.

Walesh, S. G. 2012b. "The BOK and Leadership Lessons Learned." Paper presented at the American Society for Engineering Education Annual Conference, San Antonio, TX, June 10–13.

Walesh, S. G. 2012c. "The Future and You." In *Engineering Your Future: The Professional Practice of Engineering*, 431–454. Hoboken, NJ/Reston, VA: Wiley/ASCE Press, Reston, VA.

Walesh, S. G. 2015a. "Creativity and Innovation as Part of the Civil Engineering BOK." Paper presented at the American Society for Engineering Education Annual Conference, Seattle, WA, June 14–17.

Walesh, S. G. 2015b. "Comparison of Today's EAC/ABET Engineering Degree Criteria to Future Capabilities Recommended in NSPE's Engineering Body of Knowledge." White paper prepared for the ASCE's Task Committee on Educational Requirements for Licensure, April 1.

EXERCISES

Notes:

1. The goal of the exercises is to provide students, usually working alone, the opportunity to think about and use the ideas, principles, and information offered in this and earlier chapters.
2. However, many circumstances and corresponding teaching/learning opportunities may arise. For example, a stated situation may be altered to meet specific concerns or needs. Such variations are encouraged, subject to the concurrence or direction of the instructor.

5.1 BOOK REVIEW: The purpose of this exercise is to provide you with an opportunity to study one book in depth about change and how to either respond to it or help direct it. Do so by identifying the book's key ideas and information, summarizing the book, critiquing it, and determining the book's relevance to your study and work. In doing so, you will be further introduced to a broad range of change literature and other sources, with the hope that you will continue to read critically in this area as one means of growing professionally. Suggested tasks are as follows:

a. Tentatively select one change book. Some possible sources are books reviewed in newspapers and magazines; books recommended by others; and books you find by searching the Internet.
b. Request approval of the book from your instructor.
c. Read the book and prepare a review in which you do the following: a) cite your book (e.g., name, author, publisher, date); b) describe some of the key information, ideas, and/or theses presented in the book; c) identify the supporting evidence; d) indicate whether or not you agree with the key ideas or theses; and e) comment on the book's relevance or lack thereof to your study and work.

5.2 CREATIVITY/INNOVATION: NATURE OR NURTURE: Organize a debate with friends who are not part of this study group. The topic of debate will be "Creativity/ Innovation: Nature or Nurture." Arrange for five participants in to be in favor of nature while five will be in favor of nurture. Now try to summarize the issues raised by each group into clusters and report the reasons why people held such views. Analyze the results.

5.3 AN OBSTACLE YOU ENCOUNTERED: Consider one of your creative/ innovative ideas which might have failed or was partially successful. Was the idea radically new in terms of technology or application area? Analyze all the factors that led to its failure. Usually one tends to identify external causes with much greater ease. Identifying the "within me" causes are more difficult as one needs to accept that they exist. Identify all external and internal causes. Describe the solution with due respect to your privacy and that of the others involved.

Now assume that you have to make a presentation of this idea of yours in front of a Venture Capitalist jury team. You hardly know the profile and background of the jury members. From your previous experience and the seven obstacles discussed in this chapter, plan for tackling all the probable obstacles. Also plan for how you will fight the "within me" enemy to gain the necessary confidence in your idea.

5.4 AN OBSTACLE SOMEONE ELSE ENCOUNTERED: Interview a person (preferably someone local, for convenience) who is recognized as being creative and/or innovative. Perhaps someone on the faculty can help you identify and connect with an appropriate person. Ask the person if he or she would share an obstacle encountered and how he or she responded. With the person's permission, prepare a summary of what you learned.

5.5 FEAR WITHIN ME: Go through Section 5.1.2. Now make a list of all mental boundaries that you have created for yourself. These can be: "I can only go for jobs that pay me a certain amount"; "I can only go to a certain type of graduate school"; "I can't dance well"; "I am not good at making friendships"; and so on.

Take one of these boundaries which you want to proactively and creatively tackle. Which one of the following four obstacles discussed in this chapter is most likely to deter you in breaking your mental boundary: fear of failure, belief that creativity and innovation are natural and not learned, reluctance to change, or complacency? What will you do about it? You may choose to keep the plan to yourself.