CHAPTER

4 Basic Whole-Brain Methods

Half a brain is better than none.
A whole brain would be better.
—*Betty Edwards, artist and author*

Objectives:

After studying this chapter, you will be able to:

- Illustrate the universality of divergent-convergent thinking
- Summarize how whole-brain methods enable intentional creativity/innovation
- Discuss the importance of method selection
- Show the value of using a series of multiple methods on a project
- Demonstrate understanding of the wide applicability of whole-brain methods
- Explain eleven basic, quickly learned, and rapidly applied whole-brain methods
- Cite the positive and negative features of each method
- Report the neuroscience basis of each whole-brain method

4.1 INTRODUCTION

The more ideas, the better is one theme in the preceding chapter. When faced with a carefully defined issue, problem, or opportunity (IPO), the quality of our ultimate decisions is likely to be better when we have more ideas—more options. We want the divergent thinking effort to be rich and varied. Most of the eleven whole-brain methods presented in this chapter will help you or you and your teams generate many and varied ideas—more than you would without them. In addition, most of the tools can also be used to complete what should be the first order of business: thoroughly defining the IPO.

4.2 ASK-ASK-ASK

In keeping with the principle that an IPO well-defined is half resolved, *Ask-Ask-Ask* is a great place to start. We ask questions to fully define an IPO so that we can eventually resolve it and not just treat symptoms. Putting a bucket under a leaking ceiling is a quick fix but, in the long run you should find the source of the leak (Fogler, LeBlanc, and Rizzo 2014). Once an IPO is defined, we ask questions to help generate ideas for resolving it. "Ask" is in the name of this method three times to emphasize that the tool goes well beyond superficial, innocuous, and obvious questions. Instead, drill, probe, and *onionize* (Fox 2000)—that is, get to the heart of the matter by peeling away layer after layer.

Your initial thought may be that the need to ask questions is obvious, so why devote time to it, why call it out as a whole-brain method? There are two reasons. First, question asking may seem obvious, but my experience indicates that many engineers (and probably many members of some other professions) are reluctant to go beyond superficial questions. Therefore, we engineers should be aware of our possible question-asking reluctance so that we can overcome it. Second, if you agree with the importance of asking questions, you may want to know about some question-asking techniques.

To fully explore Ask-Ask-Ask, we consider three reasons you may be reluctant to ask probing questions, outline five powers of questions, and describe four question-asking techniques that you may find useful. Anecdotes and examples illustrate the role of Ask-Ask-Ask in creativity and innovation.

4.2.1 Reluctance to Ask Questions: Three Reasons

As a student or a young practitioner, you may be reluctant to embrace Ask-Ask-Ask for one or more of the following three common reasons:

- **Questioning authority:** Recognize that most of us are authorities, just on different things. The person you interact with, such as a professor, your supervisor, or a potential client or customer, is an authority on one or more things. Similarly, you as a professional or aspiring professional are an authority on other things. By asking questions, you are not questioning the authority of the other person. Instead, you are revealing your own and doing it for another's potential benefit.
- **Appearing uninformed/poorly prepared:** Some people foolishly think that if they ask questions they will be viewed as uniformed or poorly prepared, that as experts they should know everything, or pretend they do. To illustrate the fallacy of that line of thought, consider this scenario: You awake with pain in your chest and are rushed to the emergency room. The doctor asks: "What's wrong?" and you answer, "Chest pain." The doctor says, "I am immediately performing triple bypass heart surgery." The pain aside, how would you feel? Might you want the doctor to ask more questions as part of a careful diagnosis of your problem before deciding how to solve the problem? Maybe the pain is caused by something you ate!

  Asking questions does not indicate that you are uninformed or poorly prepared; it should mean just the opposite. If you are well informed, you know what to ask. The type and number of questions you ask reveal your expertise.
- **Considered rude:** Someone said, "I don't care how much you know until I know how much you care." You demonstrate care, not rudeness, by preparing and asking thoughtful, probing questions in a polite, sensitive manner.

Do one or more of the preceding obstacles apply to you? If so, revisit your obstacles and try to address them. Failure to do so could hamper your creativity and innovation. Why? Because we need to first define an IPO in order to resolve it, and question asking is an important part of the definition process. Ask-Ask-Ask is a powerful whole-brain tool that challenges you to more fully use your brain and does the same for those you are conversing with.

VIEWS OF OTHERS: VALUE OF QUESTIONS

Consider some thoughts about asking questions from members of diverse professions and specialties. Management guru Peter Drucker said, "My greatest strength as a consultant is to be ignorant and ask a few questions." According to Charles P. Steinmetz, the electrical engineer who led the development of alternating current, "No man really becomes a fool until he stops asking questions." Robert Half, founder of a staffing firm, said, "Asking the right questions takes as much skill as giving the right answers." Finally, a comment from physician Jonas Salk, discoverer of the polio vaccine, directly relates to creativity and innovation: "What we think of as a moment of discovery is really discovery of the right question." (For additional thoughts about asking questions, see Views of Others: Value of Questions, in Section 5.10.)

4.2.2 Five Powers of Questions

The use of "power" in the title of this subsection is intended to suggest the benefits of asking probing questions; it does not suggest manipulating, misrepresenting, or pressuring. The overarching benefit of Ask-Ask-Ask is that it helps you define what someone or some entity wants and needs so that you, and perhaps your team, can creatively and innovatively fulfill those needs.

With that caveat in mind, five powers of questions (adapted from Leeds 2000) are as follows:

1. **Create an obligation to respond:** Remember a time in class when a teacher or professor asked you a question and then was silent? Most people's natural inclination is to fill that silence—that *vacuum*—with something, and so we do our best to answer the question. Silence is uncomfortable when a question is asked. This is what I mean by saying that asking a question creates an obligation to respond. I am not suggesting that we overtly try to cause discomfort, but am simply noting a natural tendency and recognizing its value if carefully used.
2. **Stimulate thinking of the asker and answerer:** Preparing and asking questions causes you to think more deeply and broadly about the other person or persons and their situation. Similarly, their thinking is enhanced as they respond to your questions.
3. **Provide valuable data/information/knowledge:** Recognize that although question asking reveals your expertise and your concern for another person and another's wants and needs, answers to your questions also provide data, information, and knowledge needed to resolve the challenge at hand.
4. **Put the asker in the driver's seat:** You can use questions to gently direct a conversation to topics that could be potentially useful to you and those you hope to assist. Furthermore, if you tend toward introversion, asking questions enables

you to start a conversation and then steer it in a potentially productive direction. Most people will respond to thoughtful, positive questions and appreciate the attention (Walesh 2004).

5. **Enable people to persuade themselves:** Thoughtful questions and the thinking they stimulate help to define IPOs and move all parties toward an IPO's resolution. The question-asking and -answering process tends to go beyond symptoms to causes, define constraints, reveal assumptions, distinguish between wants and needs, and suggest some ways to resolve the IPO.

To benefit from the five powers of questions, we need to listen. Go beyond just hearing, which is one of the six senses (Section 2.4.1) and requires little effort; it comes naturally. Move into listening, which is a skill and demands effort. Listen attentively for facts and listen empathetically, aided by sense of sight, for feelings. Facts and feelings define an individual's wants and needs and what the individual is inclined to do about them.

4.2.3 Four Question-Asking Techniques

Ask-Ask-Ask can yield many benefits and, if the situation warrants, prepare you to take a creative and innovative approach. With those benefits in mind, consider the following four question-asking techniques:

1. **Mix closed-ended and open-ended questions:** Use some closed-ended questions—that is, questions that can be answered with yes, no, or statements of fact. They typically begin with or include "how many," "how much," "when," or "who" (Parkinson 2009). For example, "How much is budgeted for designing the cable under the bay?" We engineers and other technical professionals tend to ask closed-ended questions. We want the facts. This is good, but not sufficient.

   Also ask open-ended questions, which often begin with or include "why," "how," or "what" (Parkinson 2009). For example, "Why are you considering designing and installing a completely new manufacturing line instead of modifying an existing one?" An open-ended question like that is intended to give others the opportunity to reflect, elaborate, and fill in the blanks. Closed-ended questions tend to end a conversation, at least temporarily. In contrast, open-ended questions are less likely to do so (Rhein 2009). Mixing closed and open-ended questions is likely to generate a very enlightening conversation.
2. **Use the Five Whys to drill down:** The *Five Whys* is a persistent questioning tactic that enables you to drill down—to get to the bottom of things—to move past symptoms and get to causes (Liker 2004). Assume you are an engineer meeting with a potential new client, the director of public works for a large municipality. She wants to solve a basement flooding problem caused by the backup of a mixture of storm water and wastewater from the combined sewer system. Based on your experience, you know that there are many possible causes of basement flooding in combined sewer systems and numerous ways—some very creative or innovative—to solve such problems, but your first priority is to begin to define the cause, so you apply the Five Whys as follows:
   - Why are the basements flooding? *Answer:* Because the combined sewer system surcharges when rainfall exceeds about 0.2 inches per hour. You could stop here, but you don't.
   - Why do the sewers surcharge during such rainfalls? *Answer:* Because the receiving stream rises above the level of most basement floors during those rainfall events. Again, you could stop the drill down questioning, but don't.

- Why does the receiving stream rise during those rainfalls? *Answer:* Possibly because the city's dam is downstream of the combined sewer system outfall.
- Why might the dam be relevant? *Answer:* Because it has a very short weir.
- Why does the dam have a short weir? *Answer:* Maybe because it was constructed over a century ago, before this small watershed was urbanized.

Notice how the Five Whys technique is likely to lead you and others to the cause of a problem, not just the symptoms, and the forces driving an issue and/or the benefits inherent in an opportunity.

In order to emphasize the importance of repeatedly asking why—of drilling down—I began each of the five example questions with *why*. Although the intent is to ask a series of probing questions, avoid lapsing into a mechanical, if not rude, *why-why-why-why-why* pattern. Instead, finesse the questions. For example, maybe the third question could be softened to "I'd really like to get an even better understanding of your flooding problem. Do you have any ideas about why the receiving stream rises during those rainfalls?"

3. **Apply the echo technique to help others expand their thoughts:** This technique (Johnson 2010) is an asking-listening aid. It helps the answerer further explain his or her want or need and helps you better understand that want or need. For example, the person you want to help says: "We've been dealing with this type of equipment failure for over three years." You repeat or echo the last few words in the form of a question—"Over three years?"—then be still and listen as the other person elaborates and gives you added insight into the problem he or she is trying to solve.
4. **Consider Kipling's six:** In saying "I had six honest serving men; they taught me all I knew. Their names were Where and What and When and Why and How and Who," English writer Kipling offers another method for effective questioning. It's hard to imagine a challenging IPO that does not have Kipling's six elements. In a variety of situations, recall Kipling's "six" and use them to guide your questions.

For additional question-asking concepts and tools, refer to Chapter 3 of *Strategies for Creative Problem Solving* (Fogler, LeBlanc, and Rizzo 2014).

4.2.4 Examples from Marketing of Professional Services

Marketing may be defined as "creating the climate that will bring in future business" (Smallowitz and Molyneux 1987), with the ultimate aim being "to make selling superfluous" (Kolter and Fox 1985). I've been fortunate to have had many diverse, good and bad, experiences in marketing professional engineering and related services and learned useful lessons as a result. You too will have opportunities to assist with marketing efforts, especially if you work in the private sector. As you may suspect, the first and most useful lesson I've learned is to use Ask-Ask-Ask right from the start. Once you or your organization identifies a desirable client or customer, ask a lot of questions before doing anything else.

Consider some examples of ideas and information I acquired and feelings I sensed over many years by asking questions of clients and potential clients (Walesh 2014). Essentially none of these items—the payoff of the questioning process—appeared in formal requests for proposals or qualifications or in other documents provided by clients or potential clients that I talked with. They were learned as a result of Ask-Ask-Ask. The kinds of ideas, information, and feelings described ahead provided valuable insight into how to proactively, creatively, and innovatively secure contracts and deliver on them.

- Wants a readily accessible project manager who is technically competent and can *communicate with all types of audiences*.
- *Hates surprises*: As an engineering firm representative, I was told I could have "one minute" with the director of public works of a community for which our firm was pursuing a large storm water planning project. Accordingly, as soon as I met him, I asked, "What do you like least about consultants?" His quick answer: "Hate surprises." He went on to say he preferred face-to-face meetings. Although our meeting was short, it did exceed one minute. More importantly, our subsequent proposal stressed communication and included many face-to-face meetings and the cost of those meetings. Our firm was selected for the project. Were we selected partly because of the question asked during the "one-minute" meeting? Maybe.
- Project team *must have local knowledge* and access to experts with national experience. Notice the contrast between this and the next unwritten criterion stated by another potential client.
- Project team must have technical expertise but no local history, presence, or interest in order to provide complete objectivity. The *no local history, presence, and/or interest* criteria described the firm I worked for, and we were selected for the project and follow-up projects.
- Wants *no more public involvement* other than what is absolutely necessary.
- Wants proactive, *high-profile public involvement* from day one. Note the contrast between this and the previous requirement, which stresses the extreme differences in (often unwritten) client and customer expectations and which you need to know if you want to earn the right to serve certain clients.
- We want our project to *gain national attention* through presentations and papers co-authored by us and our consultant.
- During the course of this project, we want one of our engineers to learn how you *operate the computer models*.
- This project is really all about money. *How are we going to fund* whatever solutions you recommend?

To reiterate, when Ask-Ask-Ask is applied during the marketing phase of a potential project, it yields supplemental and often crucial ideas, information, and feelings. They can be used to proactively, creatively, and innovatively secure contracts and then, in similar fashion, deliver on them.

4.2.5 Additional Thoughts about Asking Questions

If we essentially only use one type of question and/or we accept superficial or shallow answers, we risk making unnecessary assumptions or creating a false sense of getting adequate information (Rhein 2009). We may see just the tip of the iceberg, mistake it for the whole iceberg, and then inadvertently fix a symptom rather than resolve the IPO, or our questions may fail to cause the kind of thinking that generates creative and innovative ideas.

Electrical engineer Fruechte (2014), former director of a research and development laboratory, shares a story that illustrates the importance of asking stimulating and insightful questions. He says that personnel were asked to offer new ideas for future automobiles, and the results were vague and unimaginative. However, when asked for ideas to develop a "car that never crashed," the response was amazing. Electrical and electronic specialists had ideas for putting varied devices into cars to sense other vehicles and other objects around them. Mechanical engineers were excited by the possibility of designing structures that "did not need to

withstand a crash since it never would occur." Thoughtful and focused questions are likely to generate thoughtful and focused answers.

Engineering professor Eris studied the effect of what is referred to here as Ask-Ask-Ask on the quality of team solutions to challenges. He sought to determine the role of questioning in encouraging imagination and in arriving at effective results. Eris concluded that "the most effective teams asked the most questions and the questions they asked were evenly balanced between generative [divergent] and convergent" (Goldberg and Somerville 2014).

I encourage you to ask many and varied probing questions, but I also urge you to be prepared. For example, assume a professor in your department connected with a local manufacturing firm offers to have a student team tackle one of the firm's technical problems within the senior project program. As a representative of your senior project team, you're scheduled to meet with an engineer at the company. Clearly, you want to prepare for the meeting by gathering basic information about the company; don't go in cold—do your homework. Then, ask probing questions informed by that basic background information.

Finally, specific question-asking methods aside, I urge you to talk to strangers in various settings. The strangers might be students, faculty, staff, other employees, or people on the street. This advice is likely to be contrary to the "don't talk to strangers" advice you received as a child. However, that was then, and this is now. In her book *How to Work a Room,* consultant Roane (1988) challenges readers to "work the world." She urges us to adopt the philosophy that we are surrounded by opportunities to ask questions, learn, and expand our networks, but we often have to take the initiative, whether we are at the university, at work, running personal errands, sitting in an airport between flights, or attending a conference.

Will talking to strangers always provide useful information or a new contact? Certainly not. However, Roane says: "That's not the point. The point is to extend yourself to people, be open to whatever comes your way, and have a good time in the process . . . The rewards go to the risk-takers, those who are willing to put their egos on the line and reach out—to other people and to richer and fuller lives for themselves."

PERSONAL: INTROVERTS MAKE GOOD ASKERS

As an example of talking to strangers, I obtained a rewarding, multiyear consulting arrangement because I approached a speaker after his presentation at a conference. I complimented him on his presentation, mentioned that we seemed to share technical interests, exchanged business cards, and, as they say, "one thing led to another."

I tend toward introversion, as do the majority of engineers. Partly because of my introversion, I've made an effort to approach strangers in a variety of business, professional, and other settings and ask lots of questions. Rather than talk about me, unless others indicate interest, I ask questions and give others opportunities to talk, including talking about themselves, which some seem to enjoy doing. TV commentator Rooney suggests, "In a conversation, keep in mind that you're more interested in what you have to say than anyone else." This question-asking approach has provided many positive results. Like hockey great Gretsky said, "You miss 100 percent of the shots you never take." Asking questions is like taking shots; you have little to lose and much to gain.

Maybe persistent question asking, whether closed- or open-ended, using the Five Whys, the echo technique, or Kipling's six, just doesn't seem to be your forte in academic or professional matters. In that case, experiment by asking more questions in low-risk situations. For example, say to the cashier at a restaurant, "I like the new menu. Why did you make the changes?" Then, ask a follow-up question. Or the next time you attend a concert, approach one of the performers during an intermission or after the event, and ask a question or two. My experience with this type of low-risk question asking is that the other person typically responds favorably to my interest and I learn. It can be win-win for you and others, and in the process you will become more adept at Ask-Ask-Ask and increasingly use it in your student and practitioner roles.

4.2.6 Neuroscience Basis

Ask-Ask-Ask fully engages the left hemisphere, in that broad and deep thought is needed to prepare and then articulate meaningful questions, listen carefully to the responses, and then ask productive follow-up questions. In addition to hearing the facts, the empathetic listener engages his or her right hemisphere to "hear" and "see" the emotions accompanying the answers. On hearing the answers and then going on to other activities, the questioner's subconscious mind is very likely to work on the answers and then share some additional insights with the questioner.

4.2.7 Positive and Negative Features

The most powerful aspect of Ask-Ask-Ask is that it is, by far, the best way to define an IPO prior to resolving it. This method seeks to engage those who are most interested in resolving an issue, resolving a problem, or pursuing an opportunity by probing their minds for relevant concepts, ideas, facts, and feelings. As noted in Section 6.2.2, we engineers are ultimately in the people business, serving engineering, so let's focus on those people who may have engineering needs we can fill. On the negative side, some student and practicing engineers will not fully embrace Ask-Ask-Ask. Fear of questioning authority, appearing unprepared, and seeming rude will deter them. To those people, I repeat my earlier suggestion to at least experiment in nonthreatening situations with probing questions.

4.3 BORROWING BRILLIANCE

Engineer, entrepreneur, and author Murray (2009) argues, in his book *Borrowing Brilliance*, that the most effective path to creativity and innovation mixes and matches the concepts of others, especially when the others are in disparate fields. He repeatedly suggests, hopefully tongue-in-cheek, that his approach is a game bordering on stealing. For example, he says, "My personal approach to creative thinking was pretty much hack, I just stole or borrowed ideas from other places." He also says, "Since ideas are born of other ideas, this creates a fine line between theft and originality."

Murray may have some fun with "borrowing brilliance" and suggest that it's stealing, but any of us who conduct scholarly research and participate in other professional endeavors know that we build on the work of and stand on the shoulders of others. "If I have seen farther than others," said British scientist Newton, "it is because I was standing on the shoulders of giants." We also recognize that scholars cite their sources and, as appropriate, obtain permission to use the intellectual products of others.

4.3.1 Six Steps

Murray's Borrowing Brilliance consists of six steps for constructing a creative and innovative idea. I suspect that many student engineers interested in creativity and innovation will be attracted to a six-step or similar approach. In fact, except for some of the terminology, Murray's six steps as described here may be viewed as an enlightened version of the engineering design process. The six steps are as follows:

1. **Defining:** Let's define the problem we are trying to solve and, I must add, the issue to be resolved or the opportunity to be pursued. This broader perspective is important because engineers and similar scientific-technical professionals, starting from their time as students, are very adept at solving problems, but they also have the potential to prevent problems from occurring, to identify and pursue opportunities, and to address broader issues.
2. **Borrowing:** Look for ways to borrow ideas from situations having similar problems.
3. **Combining:** Combine and connect the borrowed ideas.
4. **Incubating:** Temporarily step away from the problem-solving process, enabling the combinations and connections to incubate and provide one or more solutions; that is, provide time for the subconscious mind to work.
5. **Judging:** Evaluate each potential solution's strengths and weaknesses.
6. **Enhancing:** Seek to remove the negatives and enhance the positives of potential solutions, and then select the best one.

4.3.2 Examples of Borrowing Brilliance

Murray offers informative examples of creative and innovative efforts that built on the work of others—that borrowed brilliance—including the following:

- **Reusable type printing press:** As explained in Section 1.3.2, Guttenberg borrowed woodblock printing from the Chinese, weapon and coin forging from the Romans, and the screw press from the winemakers and olive oil producers to innovatively design the reusable type printing press (Boorstin 1985; Murray 2009).
- **Theory of evolution:** To create his evolution theory and publish *On the Origin of the Species* in 1859, Darwin borrowed from biologists who cataloged species. However, biologists cataloged differences in species, whereas Darwin cataloged similarities during his five-year voyage as naturalist on the HMS Beagle. Darwin also borrowed from geologists, particularly the English geologist Lyell, who published *Principles of Geology* in 1830. Lyell's book argued that geological features represented the cumulative effects of various processes, such as wind, water, and precipitation occurring over long periods of time. This stimulated Darwin to think about the effect of long periods of time on biology (Boorstin 1985; Murray 2009).
- **Automobile assembly line:** The Ford Motor Company borrowed from meat-packing companies when developing the moving assembly line between 1908 and 1915. Ford workers visited the Swift meat-packing plant in Chicago and saw how it "used a moving hook and conveyor system [and workers fixed in place] to disassemble a cow" (Murray 2009). One Ford person who visited a Chicago slaughterhouse said, "If they can kill pigs and cows that way, we can build cars that way" (Brinkley 2003).

  Ford borrowed the disassembling carcass system, reversed it, and in 1913 produced a more efficient process for assembling cars. The company created the first version of today's very sophisticated process for manufacturing cars and numerous other products. Cars—being assembled, not disassembled—move

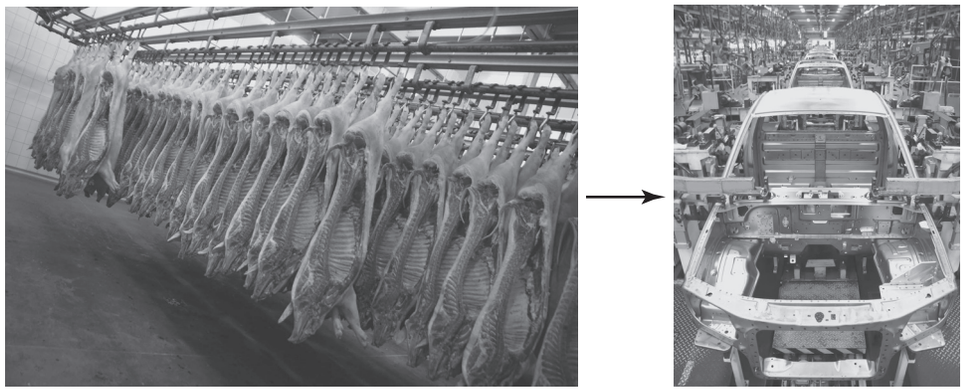


Figure 4.1
Ford borrowed the means for efficient disassembly of carcasses from the meat-packing industry to create the means for efficient assembly of automobiles.
(Beata Kulasik/Fotolia; Gjeerawut/Fotolia)

past fixed stations where workers and robots add value to each car. In summary, the Ford Motor Company borrowed a fundamental idea from the meat-packing industry to create the automobile assembly line (Figure 4.1; Brinkley 2003; Murray 2009).

What IPO do you face that might be resolved by borrowing an approach or process from a very different discipline or specialty?

4.3.3 Ten Supporting Principles

Murray (2009) offers ten principles to support his six-step Borrowing Brilliance process. Even if you are not explicitly using Borrowing Brilliance, one or more of the following principles may enhance your creativity and innovation effort:

1. **Get out of our silo:** Look close by, but also far and wide. Murray states: "The further away from your subject you borrow materials from, the more creative your solution becomes." Recall Guttenberg the printer borrowing from wine makers, Darwin the biologist borrowing from a geologist, and Ford the automobile manufacturer borrowing from slaughterhouses. In Section 6.3.3, we will learn about Philo Farnsworth, the inventor and electronics expert, who borrowed from farming to invent television, and Section 6.6.3 tells the story of a Japanese engineering team that borrowed from birding to redesign the lead unit on a high-speed train.
2. **Recognize patterns and inconsistencies within them:** Observation of patterns and their distribution or dispersion is an important part of creating. For example, in the 1660s, Newton noted that although many apples fell from a tree, the moon did not fall from the sky, which led him to develop the theory of universal or mutual gravitation. He didn't know what gravity was, but by noticing inconsistencies, he determined how it behaved (Boorstin 1985; Van Doren 1991).
3. **Master the metaphor:** According to Murray, "Great creative thinkers master the metaphor. Unfortunately your English teacher may have ruined the concept for you by relegating it to a simple writing technique." Creative individuals strive to think of their subjects—issues, problems, or opportunities—in terms of a different subject. For example, Newton viewed an apple as a metaphor for the moon, Disney used a movie metaphor (storyboards, set, props, and cast members) to create Disneyland, Gates and Microsoft saw a desktop as a metaphor for software, and Zuckerberg used the college yearbook as a metaphor to develop Facebook. We also need to know when to cast out metaphors. For example, early automobile designers used horse-drawn carriages as metaphors for the first horseless carriages and as a result placed passengers in dangerous upfront positions.

4. **Hope for parapraxes:** Be aware of parapraxes, or misunderstandings, because they may enable the subconscious mind to speak to the conscious mind in a productive manner. Murray describes three types of parapraxes. The first is the familiar Freudian *slip of the tongue*; we say something we didn't mean to say, but whatever we said might turn out to be a subconscious-driven insight or good idea. The second parapraxis is the *slip of the ear*, when we hear something incorrectly, but what we thought we heard could have value. Finally, we have the *slip of the eye*; we read or see something incorrectly, and although we erred, what we thought we saw might be useful.

   For example, consider Bell's invention of the telephone, which was partly due to a visual parapraxis. Bell tried to read the book *On the Sensation of Tone*, written by the German scientist von Helmholtz and published in German. Because Bell could not read German well, he misread a passage. The passage stated that vowel sounds could be reproduced with electric tuning forks. Bell misread it as saying that vowel sounds could be reproduced using electric wires—and then he went on to make it so.

   If you realize you just said something you didn't mean to say, misunderstood something you heard, or misread some text, reflect on the circumstances. Perhaps your subconscious mind has been working on something that your conscious mind told it was important, and now your subconscious mind is trying to tell you something that may be insightful and useful.

HISTORIC NOTE: THE REAL FIRST TELEPHONE?

Telephone means a device to hear the sound of speech (*phone*) from far or from a distance (*tele*). With that broad definition in mind, we should more specifically credit Bell with inventing the electric telephone and look earlier for the invention of more fundamental telephones.

For example, about 1,200 to 1,400 years ago, someone in the Chimu Empire (in what is now northern Peru) invented a telephone. Now in the collection of the US National Museum of the American Indian, this early telephone is a gourd-and-twine device. Two resin-coated gourd speakers/receivers, each 3.5 inches long, are connected by seventy-five feet of cotton twine. If, with one person at each end, the line was pulled taut and someone spoke into the gourd at one end, the person at the other end would clearly hear what was said. As a child, perhaps you connected two tin cans with string and conversed with a friend. Anthropologists and archaeologists theorize that this early telephone was used by a Chimu "executive" to give instructions to assistants in other rooms (Baldwin 2013).

Discovery of the Chimu telephone reminds us that creativity and innovation are an essential and timeless feature of humanity. For example, because of my interest in water engineering, I once researched the origin of some of the water-related methods and tools we use today. As you may suspect, I learned that many can be traced back decades and centuries and to places around the globe (Walesh 1990).

5. **Embrace multiple hypotheses:** Work at developing the multiple working hypotheses ability; be able to simultaneously weigh various viewpoints as to the cause of a challenge or how you are going to resolve it. Accept temporary

ambiguity while recognizing its potential value. "The test of a first-rate intelligence," according to novelist Fitzgerald, "is the ability to hold two opposed ideas in mind at the same time."

6. **Take a break:** Consistent with the Taking a Break tool described later in Section 4.11, Murray says that what he refers to as the *pause in thinking about your issue* "allows the subconscious to speak and the conscious to listen." What we call *sleeping on it* has the same effect.
7. **Recognize that you may accidentally fix or create something else:** Be open to the possibility that in searching for a way to resolve an issue, solve a problem, or exploit an opportunity, you may find a way to fortuitously resolve another issue, solve a different problem, or exploit some other opportunity. See Section 4.3.4 for two examples.
8. **Focus:** When a creation or innovation appears, keep it as simple as possible. Discard useless or marginal features. Follow Albert Einstein's advice: "Make everything as simple as possible, but not simpler."
9. **Welcome critiques:** Welcome and offer sincere and specific criticism. Murray (2009) says: "Without exception, all of the creative people who have been profiled in [*Borrowing Brilliance*] were critics. They criticized the ideas of others, criticized their own ideas, and criticized themselves."
10. **Love creating, not the creation:** According to Murray, this advice recognizes the danger of an individual or team holding onto the first stage of what could be an evolving creation or innovation and thus never realizing its full potential. As he suggests, love the journey, not the destination—or what appears to be the destination.

In my view, the key to the approach described in Murray's book is to recognize the possibility of borrowing ideas, patterns, forms, and processes from other widely varying fields, subjects, or topics, as exemplified by Guttenberg, Darwin, and Ford. In the process, we may benefit from the unexpected, such as recognizing pattern inconsistencies, experiencing parapraxes, and accidentally fixing something else. Most of Murray's book is devoted to examples of the six-step process.

4.3.4 Examples of "Accidental" Creativity

Principle 7 suggests that when we focus on an IPO and persist, we may fortuitously resolve another issue, solve a different problem, or exploit some other opportunity. I place "accidental" in quotes to emphasize that the two examples presented here did not just come out of the blue with minimal effort. Each of the described creations was part of a concentrated effort. Before considering the following two examples of "accidental" creativity, recall the related Section 3.6 discussion of fortuitous errors and accidents.

Phonograph

Murray (2009) relates Thomas Edison's experience when searching for a way to automate telegraph messages as they were relayed down the line, rather than having operators read incoming dots and dashes and then reenter them. While experimenting with a prototype, he noticed that dots and dashes, when played at a high speed, sounded like human voices. This led him to invent the phonograph. Edison's search for a solution to the telegraph problem led him to the phonograph opportunity.

Suspension Bridge

For another example of "accidentally" fixing something else, consider the creation of the world's first major suspension bridge. The story begins two centuries ago in

Figure 4.2
The 150-foot-span Craigellachie Bridge in Scotland exemplifies the iron bridges designed and built in Britain in the late 1700s and early 1800s.
(Jasperimage/Shutterstock)

Wales. Scottish civil engineer Telford designed elegant iron (wrought and cast iron) bridges all over Britain in the late 1700s and early 1800s. One example is the graceful Craigellachie Bridge, shown in Figure 4.2, which was completed in 1814 in northern Scotland. The 150-foot-span bridge is constructed of cast iron and, after some modifications in 1965, is still used today (Billington 1996). These and many of his other iron bridges were innovative—but that's another story.

The Menai Strait is a waterway separating the Wales island of Anglesey from the Wales mainland. A goal was to construct a road from Holyhead on the Irish Sea in northwestern Wales to London. Crossing of the 500-plus-foot-wide Menai Strait was one of the challenges, and another was to cross the Snowdonia Mountains. In 1810, Telford considered crossing the straits with his specialty: an iron bridge. His "proposal included a construction plan to support the arch temporarily with rods that go above the bridge over temporary towers and then down to anchors at the abutments" (Billington 1996). This proposal for a temporary construction step was not implemented.

However, the point of this example is that the innovative idea of a suspension bridge was created—that is, a bridge deck supported by cables supported by towers. While Telford was looking for a temporary way to support the construction of another iron bridge, he conceived of a completely new way to permanently construct a major bridge. Think of the temporary measures we might use during construction and manufacturing. Might some of these contain ideas for use in permanent construction and manufacturing?

Sixteen years later, Telford's suspension idea became a reality. He designed a 580-foot suspension bridge across the Menai Straits, as shown in Figure 4.3. It was the world's first major suspension bridge, and it used four parallel wrought-iron chain-link cables. The original four wrought iron cables were replaced in 1941 (135 years after the original construction) with two steel cables (Billington 1996; Sandstrom 1970).

Figure 4.3
Scottish civil engineer Telford designed the 580-foot Menai Straits bridge in Wales—the world's first major suspension bridge.
(Violetstar/Fotolia)

PERSONAL: AN ACCOMPLISHED AND REVERED ENGINEER

In the summer of 2012, my wife and I were on a bus tour of northwestern Wales. We saw the beautiful Menai Straits suspension bridge and a mountain portion of Telford's Holyhead to London road. Several times, the tour guide lauded Telford's work; he's considered a hero in Scotland and beyond. Besides designing bridges, roads, canals, harbors, and tunnels, Telford had other creative and innovative accomplishments to his name. For example, he was a founder of and served as the first president of the British Institution of Civil Engineers, he published poems, he was elected a member of the Royal Swedish Academy of Sciences, and Ediburgh's Telford College—one of Scotland's largest colleges—is named in his honor (Sandstrom 1970; Smiles 1997).

The suspension bridge creativity and innovation story goes on. Telford's studies, tests, and designs stimulated more fundamental efforts by Gilbert, a Wales road commissioner who eventually became president of the British Royal Society. He developed and published a mathematical theory for suspension bridges (Billington 1996). Capturing the essence of a structure or process with a theory and mathematics is creative and innovative and enables others to benefit from the originating project. One creative endeavor led to another, which is a common occurrence. We are fortunate in most of our design work to have theory precede design—not follow it. As I mentioned in Section 3.7, creativity and innovation are applicable in all of our professional functions and beyond, including research and development.

4.3.5 A Hypothetical Example

Contemplate another example of how a team might use Borrowing Brilliance—especially the *get out of our silo* and *master the metaphor* aspects. Imagine you are part of a team or group twenty years from now that is organizing or reorganizing your national engineering consulting firm. You want to structure it in the most effective

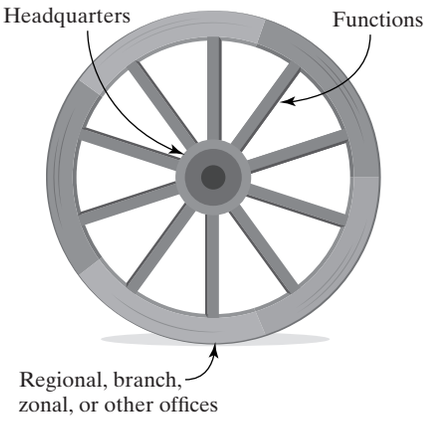


Figure 4.4
This wagon wheel is a metaphor for the initial idea of how to structure a growing organization.

manner and anticipate growth. To generate options, you look over the top of your silo and begin to think of metaphors you can borrow from the world all around you. How about a wagon wheel? As shown in Figure 4.4, the hub could represent the organization's headquarters; spokes could represent corporate functions; and the rim represents regional, branch, zonal, or other offices.

As soon as group members begin to see this potential organizational structure, which is displayed in front of them on a whiteboard, questions arise that tend to push the wheel metaphor further. One question is, "So what do the offices on the rim do?" Answering that query leads to this possibility: The rim offices use the internal services (e.g., accounting, human resources, marketing) and deliver external services (e.g., design) that are produced in the corporate office.

However, the team is not satisfied with that approach and arrives at the modified structure shown in Figure 4.5. Although the spokes still represent corporate functions, all functions are not necessarily conducted only in the corporate office. Now, some of the other offices also perform one or more of the same functions. That is, each rim entity specializes in one or more corporate functions.

On seeing Figure 4.5, someone asks, "Why do we need a corporate office?" and suggests that corporate internal and external functions be spread over various

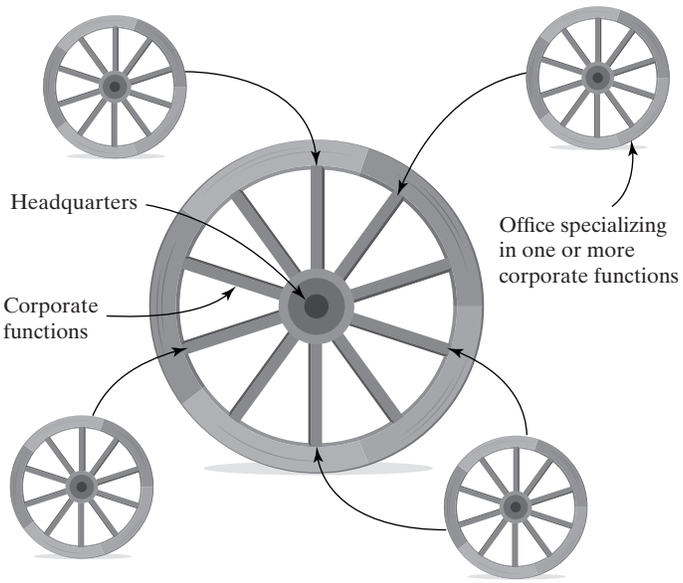


Figure 4.5
The initial organizational idea changes to put increased emphasis on the rim entities.

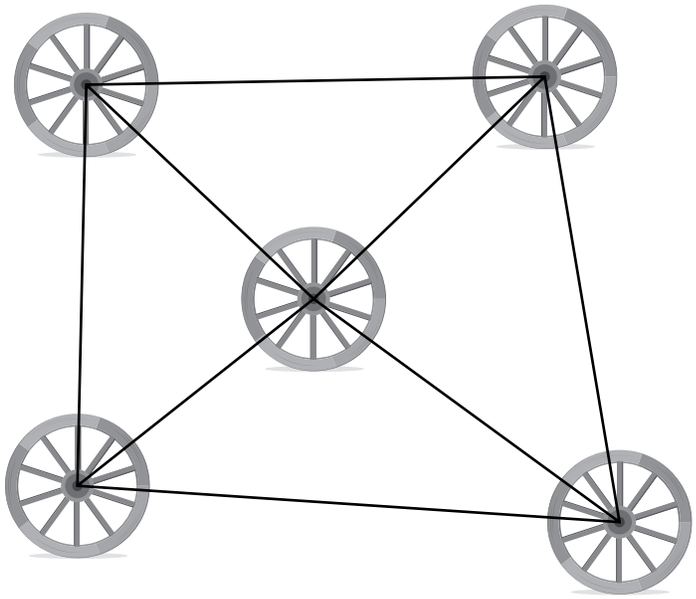


Figure 4.6
The final structure eliminates the corporate office and distributes functions across the organization based on personnel capabilities and local client/customer needs.

offices, as shown in Figure 4.6, based on personnel capabilities and local client/customer needs. With this approach, regardless of where a function originates, it could be delivered to or through any office. This hypothetical example illustrates how the evolving wheel metaphor could stimulate creative and innovative thinking about how to organize an evolving organization.

PERSONAL: TWO EXAMPLES

Although the wheel metaphor example is hypothetical, it reflects two personal experiences. The first is a conversation I had with one of the owners of an engineering firm of which I was an employee. The firm was thinking of expanding via acquisitions of other firms into other parts of the United States. The owner used the wagon wheel metaphor to explain to me how the expanded company could be organized. Each region would be a wagon wheel, and the company would be a collection of interconnected wagon wheels.

The second personal experience is from working as a consultant for an engineering firm. The firm is organized similarly to the structure shown in Figure 4.6; it has evolved to have no corporate office. Most of the time, the president is in one office and the vice presidents and other top executives are in other offices. The system appears to work seamlessly.

4.3.6 Neuroscience Basis

Consider some ways in which Borrowing Brilliance reflects our growing knowledge of neuroscience. For example, this method recognizes the mind's ability to make new connections if adequately stimulated, such as the Ford Motor Company connecting carcass disassembly to automobile assembly. Using the Medici Effect (a tool discussed later in this chapter) to form a team greatly increases the likelihood of success with Borrowing Brilliance because of the varied backgrounds of team members.

This method also makes explicit use of the subconscious mind in that Murray (2009) urges us to hope for parapraxes because they enable the subconscious mind to speak to the conscious mind. He also suggests taking a break because doing so "allows the subconscious to speak and the conscious to listen."

4.3.7 Positive and Negative Features

The most positive feature of Borrowing Brilliance is that at its core it invites ideas from everywhere, thus offering great creative and innovative possibilities. For example, at the divergent stage of searching for ways to resolve a challenging IPO, a diverse Borrowing Brilliance team can look far and wide for ideas. Other positive features of this method include that it can be applied to both defining and resolving an IPO and that it can be applied by an individual or group.

A negative aspect of this method is that such uninhibited lateral thinking is so contrary to traditional or left-brain oriented thought processes that it may not occur. Just suggesting it may invoke the negativity biases (Section 2.12) of some group members and place the team under the influence of the Einstellung Effect (Section 3.4). Such negative tendencies can be offset by an effective facilitator (Section 3.8).

4.4 BRAINSTORMING

Most people have heard of *Brainstorming*. Sometimes, the word is used as a verb, as in "let's brainstorm solutions to our problem"; in other situations, Brainstorming is a noun, the name of a method that we use individually or with a group. The word is commonly used, but I suspect that this seemingly simple method is rarely applied effectively.

HISTORIC NOTE: OSBORN'S FAITH IN CREATIVITY

The development of Brainstorming is credited to advertising executive Osborn, who described the idea-generation method in his 1953 book *Applied Imagination: Principles and Procedures of Creative Problem-Solving*. From 1952 to 1964, he also published three other books offering advice on how to be more creative. Consistent with this text, the widely acknowledged father of Brainstorming said that he wanted his readers to "become more conscious of the creative power within [their] reach" (Koberg and Bagnall 1991; Wheeler 2014).

4.4.1 Seven Steps of Brainstorming

Assume you are responsible for a functional area in your organization that is faced with a well-defined technical problem and that you decide to use Brainstorming to generate ideas for possible solutions. The suggested Brainstorming process is as follows:

1. In the spirit of the Medici Effect, invite a wide variety of participants, not necessarily a large number. For example, if this is a malfunctioning manufacturing process, invite an engineer who designs products and an engineer who designs manufacturing processes, a marketing person who understands customer expectations, a technician or technologist who operates and maintains manufacturing processes, a line worker who is closest to how the processes actually work, and an administrative person who is familiar with peripheral activities.

2. Create a nonthreatening environment so that all participants feel free to say what they think. This can be challenging in those organizational cultures in which individuals who are low down in the administrative structure are not encouraged to share ideas and information with individuals who are high up in the hierarchy. Avoid having a boss, a high-level executive, or another authority figure facilitate the Brainstorming session or even be present because some participants may be intimidated or otherwise reluctant to offer their views.
3. Pose the problem and explain the history (how we got here), and describe the desired result, such as fewer breakdowns, more production, and/or improved quality.
4. Invite—in fact, expect—everyone to offer ideas. Doing this from the get-go and keeping it going typically requires a skilled facilitator.
5. Be careful not to evaluate any ideas during the Brainstorming session. Again, a skilled facilitator is usually needed because many of us, especially engineers, want to analyze. Discourage any form of disapproval, including body language such as eye rolling, heavy sighing, shrugging, spinning a document on the table or desk, laughing at (not with) a contributor, and emailing or texting (Brenner 2007). Sometimes, individuals don't realize that they create these distractions. Distractions aside, at this stage, many and varied ideas typically begin to appear because
   - participants have brought and begin to share and reflect widely varying knowledge, skills, and attitudes;
   - some participants are very close to the problem at hand—but no one has ever asked for their views before; and
   - contributed ideas stimulate piggyback thinking and generation of more ideas by others.
6. Go for quantity of ideas, not quality (Byrne 2005).
7. Record all of the ideas as they are offered and do so in some manner, such as on a whiteboard or on newsprint, in which all participants can see the evolving list, which will serve as a stimulant.

If feasible, consider temporarily stopping the Brainstorming after Step 7 and resuming it for a short period in a day or two. This approach will stimulate cognitive processing in the subconscious minds of all or most participants. Accordingly, when the group reconvenes, new ideas are certain to appear. Conclude the Brainstorming process and then, and only then, begin to think about how you or others will evaluate and prioritize the many and varied solutions that have been generated.

4.4.2 Multivoting

Brainstorming and other idea-generation tools, such as Mind Mapping and Ohno Circle, typically yield many potential options, which then present the challenge of evaluating and prioritizing them. Multivoting, as illustrated in Figure 4.7, offers a systematic, democratic, and effective means by which a team can collectively prioritize ideas.

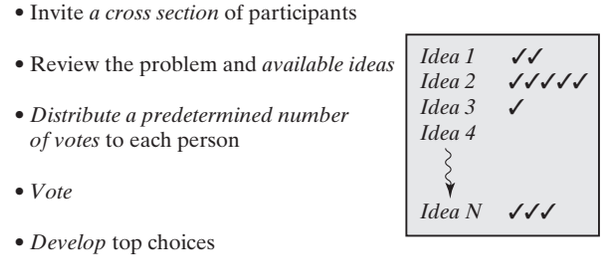


Figure 4.7
Multivoting provides a systematic, democratic, and effective way to prioritize a large number of ideas.

Begin by convening the group, which might be the original Brainstorming group or a new heterogeneous group. Set the scene by listing the available ideas in a highly visible fashion, such as on a whiteboard or sheet of newsprint. If this is a new group, then some background explanation will be required.

Give each person multiple votes. As a guideline for determining the number of votes per person, divide the number of ideas by about five. Ask participants to anonymously cast their allotted votes any way they wish, such as dedicating all of their votes to one idea or distributing their votes over two or more ideas. Participants will use their votes in accordance to the relative values they assign to options that interest them. Rank the results and then discuss one or more high-priority ideas and develop an action plan.

4.4.3 Electronic Brainstorming

Brainstorming can be conducted electronically, generally following the steps outlined previously. Cain (2012) reports that "Groups brainstorming electronically, when properly managed, not only do better than individuals; research shows, the larger the group, the better it performs." Using Figure 4.8, consider how electronic brainstorming might work.

Assume that a facilitator invites four diverse individuals to participate—and all four accept. Of course, we could have essentially any number of participants. Using email, the facilitator explains the process, describes the IPO, and invites each participant to share ideas by emailing them to the facilitator within a prescribed period, such as one day.

The first set of ideas arrives and is used by the facilitator to start an idea list. The list is immediately shared with all participants and they are asked, with their conscious and subconscious minds being stimulated by the list, to offer more ideas within one day while not sharing evaluations of the existing ideas. The process of generating ideas, adding them to an evolving list, and sending the list to participants with a request for more ideas could go on for several cycles until the process yields diminishing returns. As with conventional Brainstorming, the list could then be analyzed and prioritized and an action plan developed. Brainstorming software is readily available online. You may want to experiment with one or more software options after trying manual Brainstorming.

4.4.4 Neuroscience Basis

The modest visual aspect of Brainstorming in the form of the simple, real-time, readily seen list of ideas tends to stimulate both hemispheres of participants. If

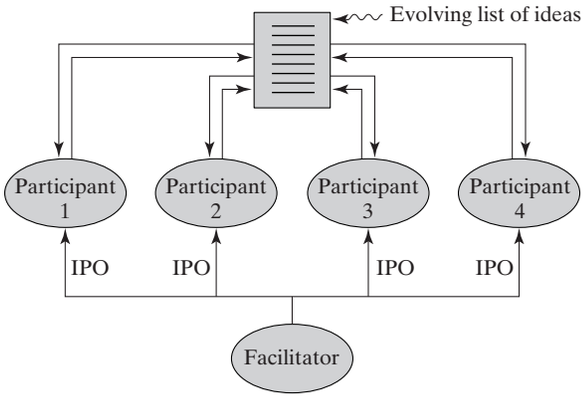


Figure 4.8
Brainstorming can be conducted electronically.

Brainstorming, a largely conscious mind process, is temporarily stopped, then useful cognitive processing will occur unnoticed in the subconscious minds of all or most participants. Therefore, when the process resumes, more ideas will appear.

4.4.5 Positive and Negative Features

The positive aspect of Brainstorming is that, with facilitation, it provides a means by which a diverse team can quickly generate many ideas. It can be used in the divergent mode to produce a list of possible causes of an IPO or a list of possible solutions to an already well-defined IPO. Other than for the facilitator, little or no preparation is required by the participants. Although you will produce more ideas if you ask invited participants to think about the topic ahead of time, thus engaging their conscious and subconscious minds, you also will generate many ideas without such preparation.

On the negative side, a study (Cain 2012) conducted by a psychologist concluded that group Brainstorming is less effective than individual Brainstorming. That is, under certain conditions individuals produced more and better ideas when they brainstormed alone versus in groups. The potential advantage of individual Brainstorming assumes that individuals will brainstorm on their own, in contrast to the more likely occurrence of effective Brainstorming if people are brought together in a focused, facilitated group (Section 3.8). Reasons given for the failure of group Brainstorming (Cain 2012) include the following:

- **Social loafing:** Some participants sit back and let others work.
- **Production blocking:** Only one person can talk or produce at a time, frustrating some others.
- **Evaluation apprehension:** People may fear appearing uninformed or even stupid.

Of course, these possible causes of group Brainstorming failure can be addressed at least in part by the facilitator, as a group works through the seven-step process described earlier. Furthermore, electronic Brainstorming can offset some of the previously mentioned reasons for failure of face-to-face Brainstorming. For example, during electronic Brainstorming, each participant will enjoy periods of solitude during which he or she can contemplate the issue and then offer thoughts, thus offsetting social loafing, production blocking, and evaluation apprehension. Finally, another way to offset social loafing and evaluation apprehension is to ask each participant to prepare a few initial ideas and bring them to the Brainstorming session.

4.5 FISHBONE DIAGRAMMING

Fishbone Diagramming, which is also called *cause-and-effect diagramming* or *Ishikawa Analysis* (Dhillon 2006; Hensey 1993), provides a systematic means for identifying widely varying possible causes of a problem. It's a diagnostic tool that can be used by an individual or a group to enhance the breadth and depth of the search for possible causes of or motivations for an IPO. The strongest argument for using Fishbone Diagramming is this principle: an IPO well-defined is half-resolved.

4.5.1 Description and an Example

Let's explain the Fishbone Diagramming process with an example based on one of my consulting experiences. Assume that you and your very diverse team (e.g., engineers, technologists, technicians, maintenance personnel, construction personnel) are studying a recently constructed storm water retention facility that seemingly failed to protect downstream properties during a large rainfall event.

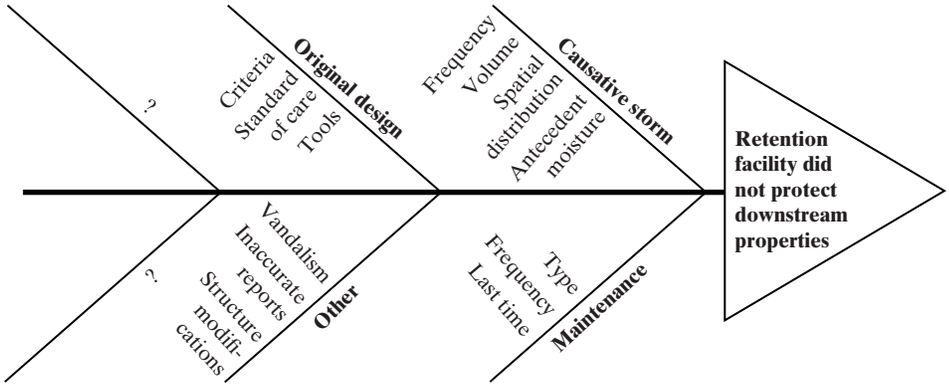


Figure 4.9
Fishbone Diagramming provides a systematic means for identifying widely varying possible causes of a problem such as suspected failure of a storm water retention facility.

A storm water retention facility is typically designed and constructed to serve multiple purposes in an urban area. It normally contains some water for aesthetic and recreation purposes. However, its configuration and outlet works allow the facility to temporarily store additional water (storm water runoff) for later slow release to avoid downstream flooding.

Your group wants to determine the probable cause or causes of the apparent failure. Begin by drawing the "head" of the fish, as shown in Figure 4.9, on a whiteboard or sheet of newsprint so all can see it. Write "Retention facility did not protect downstream properties" in the head.

Next, collaboratively identify "bones," as shown in Figure 4.9—that is, categories of possible causes of failure, such as the causative storm, maintenance, the original design, and others. Detail each bone, make judgments as to the likely cause or causes of failure, and develop an action plan to further investigate the most likely causes. The process of having an individual or team carefully identify each bone and then detail each one encourages breadth and depth of up-front thinking and reduces the likelihood of jumping to incorrect conclusions.

PERSONAL: THE IMPORTANCE OF DOCUMENTATION

The Fishbone Diagramming example is based on one of my consulting assignments. I was retained by a city as an objective outside consultant to investigate the cause or causes of flooding that occurred immediately downstream of a recently designed and constructed storm water retention facility. My conclusion: The retention facility "failed" because the causative storm was more severe than the design storm, the severity of which had been selected by the municipality that retained the design consultant. Prior to my analysis, some local citizens and officials were quick to blame the flooding on faulty design and/or construction. On the contrary, the retention facility performed as expected.

My experience on this and other projects indicates that no matter what is being designed by engineers, they and those they serve need to fully understand and agree on the design criteria. Furthermore, the criteria and their implications should be carefully documented.

Consider another example. An engineering firm designed an improved system of storm sewers for a community, and shortly after it was constructed a

major rainstorm resulted in extensive flood damage. The community started a legal action against the engineering firm, alleging negligence and breach of contract. I was retained as a consultant by the engineering company's law firm to determine what had happened. I concluded that the causative storm exceeded the conditions for which the piped system was designed.

However, the engineering firm had failed to document the meeting at which it and the community had agreed on the design criteria. That documentation lapse resulted in unnecessary postflooding actions, during which the engineering firm incurred large consulting, legal, downtime, and settlement costs. Within engineering practice, not documenting meetings is usually penny-wise and pound-foolish—no, ton-foolish.

4.5.2 Neuroscience Basis

Fishbone Diagramming is effective because its highly visual nature stimulates right-hemisphere processing to supplement that of the left hemisphere. The process is open-ended and stimulates whole-brain thinking because the evolving fishbone can have an unlimited number of bones and each bone can have an unlimited number of features. If this method is conducted as a series of events, ongoing stimulation of the subconscious mind will result in additional bones and/or elements of bones.

4.5.3 Positive and Negative Features

One positive feature of Fishbone Diagramming is its highly visual aspect: The fish skeleton is drawn in real time in response to suggestions offered by participants. Seeing each new bone appear stimulates individuals to think of possible additional bones. Similarly, adding a detail to any given bone challenges participants to think of additional details appropriate for other bones. Another positive feature of this method is that it can be used by an individual or a group.

The only negative aspect of Fishbone Diagramming is the possibility of giving insufficient attention to identifying all possible bones and their elements. This could result in missing a key aspect of an IPO. One way to avoid this omission problem is to work on the fishbone diagram, stop, and then resume on another day, thus giving each participant's subconscious mind an opportunity to weigh in.

4.6 MEDICI EFFECT

You will increasingly be able to influence the makeup of teams charged with meeting a challenge. Use the *Medici Effect* to select highly diverse team members. This section describes diversity, mentions the sometimes surprising novice effect, explains the four steps of successful team development, and provides examples of the creative and innovative work of diverse teams.

4.6.1 Back to the Renaissance

Assume that you are part of or leading a group that is about to tackle a challenging IPO. Recognize that success of the creativity and innovation methods presented in this chapter and in Chapter 7 usually depend in part on assembling and then energizing a highly diverse group. One way of describing the Medici Effect is to think of gathering a whole-brain team—a team composed of individuals with highly varied

left- and right-brain capabilities (Leonard and Straus 1997). As someone said, "None of us is as smart as all of us." Sutton, an engineering professor, characterizes the Medici Effect as bringing together "people who know too much and people who know too little" (Wolff 2012).

What does he mean by "people who know too much?" I don't think we can know too much. However, when someone knows a great deal about a particular topic, maybe the approach to moving forward in that topic depends too much on how it has been approached in the past. That is, the Einstellung Effect (Section 3.4) rules the thinking process. Having some team members who know "too little" about the subject at hand can offset the downside of those team members who know "too much." We'll return to this later when we discuss the novice effect.

A related aspect of team diversity is to engage one or more individuals who are knowledgeable about, and maybe even experts in, creative and innovative processes such as the principles and tools presented in this book. Their process expertise can synergistically combine the relevant subject matter expertise of some participants and the varied inputs of the other team members.

HISTORIC NOTE: THE RENAISSANCE

In advocating the practice of assembling and then energizing a truly diverse group, we are in effect using a miniversion of the Medici Effect, which formed the foundation for the Renaissance. As explained by consultant and author Johansson (2006), in the fifteenth century the wealthy Medici banking family of Florence, Italy, became a strong supporter of the arts and sciences. More specifically, the Medicis and a few others brought into Florence and generously supported "sculptors, scientists, poets, philosophers, financiers, painters, and architects," which led to "a remarkable burst of creativity."

Today, we may view establishing a diverse community as simple because of the Internet, but Arciszewski (2009) notes that the process once "was a rare occurrence [because] the Dark Ages was a time when interactions between individuals of different disciplines were not the norm." The interaction of highly varied individuals living in comfortable and interactive physical proximity in Florence gave birth to the Renaissance. You can use the six-century-old Medici Effect to establish a Renaissance-like atmosphere in your organization.

The Medici Effect can be used in your team efforts, beginning as a student, to stimulate creative and innovative means of resolving and solving problems and pursuing opportunities. Doing so requires assembling a diverse group and then diplomatically choreographing its efforts so that the group appreciates and draws on its diversity.

4.6.2 Types of Diversity

Consider the following kinds of diversity you might seek, depending on the IPO, when forming a team charged with thinking collectively in a creative and innovative manner (based in part on Johansson 2006):

- **Disciplines:** For example, engineering, accounting, planning, law, technology, surveying, architecture, or medicine.
- **Specialties:** For example, robotics, tall structures, private development, nanotechnology, precision agriculture, finance, or thermal imaging.

- **Positions:** For example, project architect, vice president, project manager, technical specialist, human resources manager, research and development director, president, resident project representative, marketing manager, administrative assistant, chief surveyor, chief executive officer, technologist, mayor, or engineer intern.
- **Attitudes:** That is, how various individuals think and feel in response to a fact or situation, such as optimistic or pessimistic and proactive or reactive, and degrees of commitment, sensitivity, and thoughtfulness (American Society of Civil Engineers 2008).
- **Ethnicity:** For example, racial, religious, linguistic, historic, or physical characteristics.
- **Geography:** Familiarity with different physical geographies may have implications for some IPOs.
- **Age:** Members of generation Y and generation X, baby boomers, and traditionalists offer highly varied experiences, knowledge, and skills.
- **Gender:** For example, as noted in Section 2.14.6, females are generally considered better communicators.
- **Personality profiles:** For example, leader, task person, people person, or free spirit.
- **Novices:** That is, individuals whose experience and expertise are not related to the IPO at hand and its possible resolution. Examples include a new employee, a first-year engineering student or a nonengineering student, a colleague who is employed elsewhere, your former professor, or a co-op student who just started working in an engineering office.

The last two of diversity characteristics—personality profiles and novices—are discussed in more detail in the next sections.

4.6.3 Personality Profiles

Informed by experience, we know that we collectively represent widely varying personalities. "Personality is generally agreed to be a group of behavioral characteristics typically exhibited by an individual. . . . Personality can be seen as a bundle of habitual responses." Your personality is determined by genetics and learned behavior (Carter 2009).

As suggested by the preceding list of diversity types, diverse personality profiles are desired when creating teams for creative/innovative work. Many personality-profiling systems are available, such as the Myers-Briggs Type Indicator (Culp and Smith 2001; Wankat and Oreovicz 1993), Whole-Brain Model (Herrmann 1996), Personal Profile System (Carlson Learning Company 1994), Behavioral Types (Alessandra 2015), and People Mapping (Lillibridge 1998). Although delving into an array of these profiling techniques is beyond the scope of this book, a brief look at one system—People Mapping—can help you see the potential value of personality profiling.

With People Mapping, after completing a questionnaire, each participating person is placed into one of the following four personality types as their primary tendency:

- **Leader:** Will want to know about long-term impacts of an idea
- **Task person:** Will want to know how an idea would be implemented
- **People person:** Will want to know how an idea would impact others
- **Free spirit:** Will want to know what is unique/exciting about an idea

Although most of us can relate to and appreciate each of the four personality traits, People Mapping's premise is that most of us have a dominant trait. Having

each of the four dominant traits represented on a team enhances the Medici Effect and strengthens the team. The Medici Effect aside, understanding your personality profile will give you a better understanding of you! Recognizing the personality profiles of others helps you work more effectively with them.

4.6.4 The Novice Effect

Why are novices included in the list of desirable types of diversity? Because we want to stimulate the novice effect. This is the sometimes surprising and powerful result of giving a task normally done by an "expert" to an "amateur" (Gross 1991). The amateur, unencumbered by much relevant expertise, may have a creative/innovative idea for addressing your IPO. The novice, unlike an expert, does not know what can't be done and what won't work. Many of the creativity/innovation examples presented in this text illustrate the novice effect, such as the creation of Velcro by an electrical engineer (Section 1.3.2), the weed eater by a dance instructor (Section 6.6.1), and masking tape by a sandpaper salesperson (Section 6.6.2).

PERSONAL: NOVICE EFFECT IN ACTION

Shortly after starting work as an engineering dean many years ago, I noticed that department chairpersons in the engineering college invested a large amount of time each semester scheduling engineering faculty, students, and classrooms for the next semester and I understood this to be an important and complex process. On asking one of the chairpersons how his group carried out the task, he pointed to his head and said "it's all up here."

In the spirit of helping, I suggested that the chairpersons' efforts might be reduced if they involved my administrative assistant. Prior to my hiring her, she had scheduled work in a production line at a local manufacturing plant. Furthermore, she was a computer whiz and welcomed challenges. The department chairperson didn't think the administrative assistant could be helpful because, among other things, she wasn't even a college graduate. However, he reluctantly agreed to let her sit in on the meetings at which the chairpersons did the scheduling.

Within a year, she had most of the scheduling process on a spreadsheet and from then on saved several personnel a lot of time every semester. She didn't know what she couldn't do—the novice effect in action.

4.6.5 Four Steps for Successful Team Development

Assume that, as the leader of a team of students, you just pulled a highly diverse group together (in keeping with the Medici Effect) and asked the group to address an issue, solve a problem, or pursue an opportunity. Some group members know some other members, but the individuals have not worked closely together. Or, assume you are a new member of such a new team. The team plans to meet face-to-face and via conference calls.

The challenging IPO aside, the immediate priority is to enable the group to work together. You plan to use some of the whole-brain tools described in this chapter and in Chapter 7 partly to break down barriers as discussed in Section 3.2.3, but first you have to get the team acquainted and moving forward. This may be difficult because the group is by design composed of very diverse individuals who are not well acquainted and have not functioned as a team.

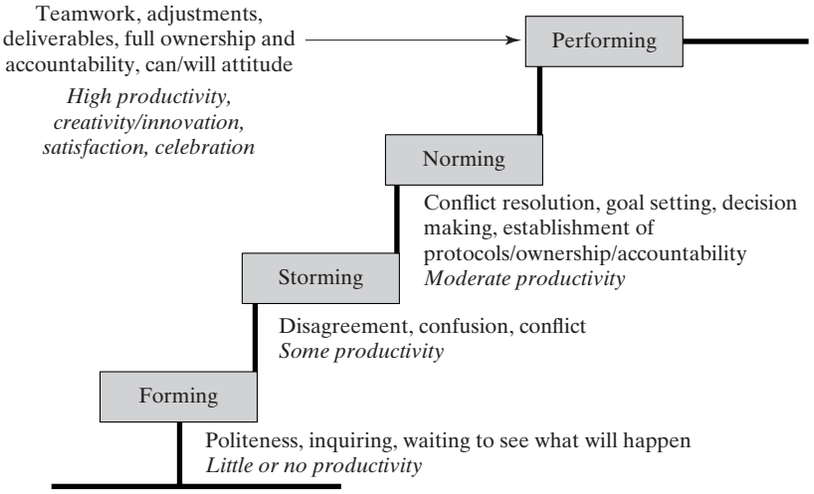


Figure 4.10
Diverse teams often must work through a four-step development process.

Forming

As shown in Figure 4.10, the first step is Forming. At this stage, team members start to become acquainted (some have never met), and the group begins to become organized. This is usually a polite and pleasant interlude, with little or no productivity, while team members wait to see what will happen.

Storming

However, when the group tries to do some work and make some decisions, the second step, Storming, often occurs, as suggested by Figure 4.11. Storming is fueled partly by the group's diverse design. Factions form and disagreements, confusion, and/or conflicts occur. Some individuals knock heads. Team members may have very different understandings of the group's purpose and/or ways to address it. Nevertheless, some productivity may occur. More importantly, Storming can hamper, if not destroy, the effectiveness of a truly diverse team.

Consider some ways to minimize the turmoil of the second step and mitigate Storming:

- **Arrange an early face-to-face meeting:** Increasingly, because of geographic separation coupled with more communication options, we form or join virtual teams.

Figure 4.11
Resolving the potential storming step is one of the challenges in implementing the Medici Effect.
(DragonImages/Fotolia)

Typically, members are geographically separated and often are employees of different organizations. Many have never met most of the others. I urge a very early face-to-face meeting of a new virtual team, even if the monetary costs are high, because the teams may be virtual, but their relationships should be real (King 2007). We want to avoid Team In Name Only (TINO; Brenner 2008). Most of us are much more likely to communicate and collaborate electronically once we've met face-to-face. We want another person to be more than an email address. The desired team creativity/innovation ultimately comes from connectivity, not proximity. The early-on, upfront, face-to-face meeting can be the foundation of that connectivity.

- **Provide context:** By context, I mean, how did we get here? Looking forward, where do we want to go? Who cares about the results and why?
- **Agree on terminology:** I find that terminology is often a major stumbling block. For example, I served on a committee with the charge of "entering the professional practice of civil engineering." Defining this deceptively simple-looking expression took a major effort but proved valuable and enabled the committee to move forward. Agree on terminology and put it in writing. Maybe start a glossary, especially if one team deliverable is a report.
- **Encourage sharing:** Encourage everyone to speak up. Recall why we assembled all these different people in the first place. Leverage the diversity. One way to draw on diversity, especially if you are the group's leader or facilitator (Section 3.8), is to go beyond the golden rule. Rise up to the platinum rule: Instead of treating team members as you would like to be treated, strive to communicate with them as you perceive they would like to be approached based on what you are learning about their personality profiles and other characteristics.
- **Respect:** Roles often follow from diversity. Assume someone volunteers to edit the team's report because of his or her writing knowledge and skill. Try to defer to that person on routine editing decisions.
- **Establish meeting protocol:** For example, prepare agendas and minutes, mute cell phones, expect everyone to participate, never exceed one hour, and honor action items. You could also consider somewhat higher-level protocols, such as 1) transparency—issues are discussed here, involving the entire committee, team, or group, and decisions are made here; and 2) no repercussions—honest views are expected and those who express them will not be penalized (Tompkins 1998). One of my clients went so far as to adopt *rules of the road* for the management group, frame them, bring them to meetings, and set them in the middle of the conference table for all to see.

Norming, Performing, and Maybe Mourning

Step 3, as shown in Figure 4.10, is Norming, which begins when most group members see diversity as a source of energy and synergy, as the fount of creativity and innovation. The interpersonal difficulties of the Storming step fade away. The team starts to produce by applying some of this text's whole-brain tools. Step 4, Performing, is the ultimate step. This is where the real work gets done.

Sometimes, team members experience a fifth step, Mourning. That is, the joint effort was so uplifting, satisfying, and productive that members miss the group when the creative/innovative effort is completed.

4.6.6 Avoiding the Cloning/Sameness Approach

When an individual gathers a group to address an issue, solve a problem, or pursue an opportunity, one tendency (perhaps subconscious) is to clone oneself—or if not that extreme, to gather very similar individuals, as in, "Let's get the usual gang

together, all of whom are mostly like us, to kick this around." Although this natural cloning or sameness inclination is likely to provide comfort, it is not likely to promote creative or innovative thinking. Homogeneity of participants stifles creativity and innovation, whereas heterogeneity stimulates them.

The tendency towards sameness also occurs when groups or teams self-organize. That is, when members of a large group are asked to form small groups or teams, the natural inclination is to gravitate toward similar individuals: similar in appearance, education, background, philosophy, and other features. Psychologists call this the similar attraction effect, and "it can have a devastating impact on our efforts to create diverse teams," according to consultant Johansson (2006).

Herrmann (1996), who conducted extensive left- and right-brain investigations, also studied the effect of team composition on the resulting degree of creativity/innovation. He concluded:

- *Homogenous teams* will tend to experience high communication effectiveness; require little time to make decisions, such as how to address an issue, solve a problem, or pursue an opportunity; and arrive at results that are *low in creativity/innovation.*
- *Heterogeneous teams* will tend to experience low communication effectiveness (at least initially, as explained in the discussion of the four steps of effective team development), take a long time to make decisions, and arrive at *highly creative/innovative results.*

If you want a group to function creatively and innovatively, don't let cloning and sameness considerations drive team formation. To reiterate, diversity means diversity; it does not mean homogeneity, nor does it mean exclusivity, as in the idea the only high-ranking individuals in the organization should be engaged in addressing challenging IPOs.

PERSONAL: EVERYONE CAN CONTRIBUTE

I recall drafting a proposal to conduct a creativity and innovation workshop for an engineering firm. The proposal advocated including technicians and administrative assistants in a group of engineers that would participate in the workshop. A proposal reviewer said, "It is not clear to me how the laboratory technician or the administrative assistant would necessarily help." Perhaps that is a common response to the kind of diversity I am advocating. Frankly, a laboratory technician and an administrative assistant are likely to hear, see, and think about things relevant to the IPO at hand that others will not.

If anyone wants to learn what is really going on and should be going on within the office of an engineering organization, ask an administrative assistant who has survived several bosses and many employees and has been around for a long time. If you want to learn more ways in which designers in offices could produce more useful plans and specifications, ask a technician who works in the field observing or directing manufacturing or construction in accordance with those plans and specifications.

4.6.7 Examples

Despite having heard the argument for the Medici Effect and the effectiveness of teams composed on the basis of highly varied diversity, some of us may still view

creativity and innovation as being primarily the result of individual effort—personal genius in action. For example, William Shakespeare, Thomas Edison, and Steve Jobs come to mind as solo, heroic creators and innovators. But were they? Probably not:

- "Some scholars are now saying that the plays we attribute to Shakespeare, among the greatest works of genius in all civilization, were probably created by a team" (Cooper 2006).
- Edison's Menlo Park, New Jersey, laboratory "was filled with highly-talented innovators" even though Edison "took most of the credit for his breakthroughs" (Cooper 2006).
- The late Steve Jobs, who led Apple, may not have been the highly individualistic creator he was commonly viewed to be. For example, he was known for giving unique, casual, conversational, and passionate presentations when releasing new products. Did he create these presentations by himself? No, noted communication writer Reynolds (2008), who said that Steve Jobs "and his team prepare and practice like mad to make sure it looks easy."

During World War II, the German navy quickly assembled groups of submarines, called *wolf packs*, to attack and sink allied ships. Any German submarine that observed an allied ship or a convoy of them would use a coded message to call in other submarines, and then the wolf pack would converge and destroy the ship. They were effective: For a year or two, the Germans sank an average of fifty ships per month, with total casualties of over fifty thousand (Johansson 2006). The allies had to break the code called Enigma so that they could warn and protect their ships and take other military offensive and defensive actions.

Accordingly, the British intelligence unit gathered a diverse group of potential code breakers, in Medici Effect style, who worked in a Victorian mansion northeast of London. The group included linguists, mathematicians, chess grand masters, scientists, crossword puzzle experts, and individuals from many countries all committed, for various reasons, to breaking Enigma. Their achievement was described as the greatest intelligence triumph of World War II or any war because the allies could now read Germany's highly secret messages (Johansson 2006; Macintyre 2012).

4.6.8 Neuroscience Basis

The Medici Effect connects to our expanding neuroscience knowledge in two ways. First, it recognizes that although our brains may look similar, each of us has a unique knowledge-skills-attitudes set and personality profile, which, among other implications, means that each person can make one-of-a-kind contributions to any team's creative/innovative effort. Second, and as explained by the novice effect, sometimes what we do not know about a particular IPO enables us to make fresh and powerful contributions, given the ability of our brains to see connections among areas of expertise.

4.6.9 Positive and Negative Features

On the positive side, research and experience indicate that diverse groups typically resolve IPOs in a creative or innovative manner. A possible negative feature of the Medici Effect is the challenge of working with a highly diverse group, especially guiding it through the possible Storming stage. Another potential negative for some users is that to be effective, the Medici Effect should be used with one or more other methods described in this chapter or in Chapter 7; this may cause some confusion. The suggested approach is to use the Medici Effect when forming a team that will be charged with taking on a challenging IPO and doing so in a creative and

innovative fashion. Then, suggest one or more other methods from this chapter or Chapter 7 that the group could use to get started.

4.7 MIND MAPPING

Mind Mapping (Arciszewski 2009, Gross 1991), also known as *clustering* (Rico 2000), is a highly visual method that helps an individual or team address an issue, solve a problem, or pursue an opportunity. It is effective in initially defining the IPO and then, by applying Mind Mapping again, in identifying potential ways to resolve it.

HISTORIC NOTE: ORIGINALLY A NOTE-TAKING METHOD

Mind Mapping was advanced in the 1980s by Buzan, a British psychologist, educator, and author of books about the human brain (1983, 1984, 1991). Early on, he suggested that Mind Mapping was an effective tool for note taking, which may have been inspired by Leonardo da Vinci's method of note taking (Gelb 2004). More specifically, Buzan suggested the following when taking notes (Buzan 1983): "Rather than starting from the top and working down in sentences or lists, one should start from the center of the main idea and branch out as dictated by the individual ideas and form of the central theme."

Therefore, Mind Mapping was originally used by an individual to organize ideas he or she hears from others. However, as stressed in this chapter, Mind Mapping evolved to also be used by a team to define an IPO and to be applied prospectively to prepare a presentation, construct a project plan, identify options, and for other forward-looking, creative/innovative efforts. Stressing the whole-brain aspect of mind mapping when used in a prospective manner, Gelb (2004) says, "Mind mapping frees you from the tyranny of premature organization, which stifles your generation of ideas."

4.7.1 A Team Mind Map in Action

As a means of describing the Mind Mapping process, consider Figure 4.12, a mind map developed by a group of four. They were addressing a problematic pond in a residential area. A twenty-five-minute Mind Mapping session was used to define the problem. For the purpose of sharing the result, the subject of the mind map is not important, other than to say that the topic being addressed was poorly defined at the outset, in that the four individuals had different perceptions of the problem. The important aspects are the resulting format and the process used to create it.

To get started, state and show the topic in a manner visible to everyone, such as on a whiteboard or newsprint (in this case, as indicated in Figure 4.12, the topic was a pond problem). Ask each participant, "What does this make you think of?" or "What comes to mind?" Whatever pops into anyone's mind and is shared is added to the mind map in ovals connected by arrows. This tool "radiates visual and spatial cues from a central idea" (Miles 1997).

Anything goes; if someone thinks his or her idea is connected in some way to what is already shown on the mind map, then it is. As with brainstorming, don't judge any of the suggestions other than to ask for clarification. Also as with brainstorming, one or more participants may want to go into an analysis mode. The facilitator must nip this in the bud. My experience in using Mind Mapping is that once

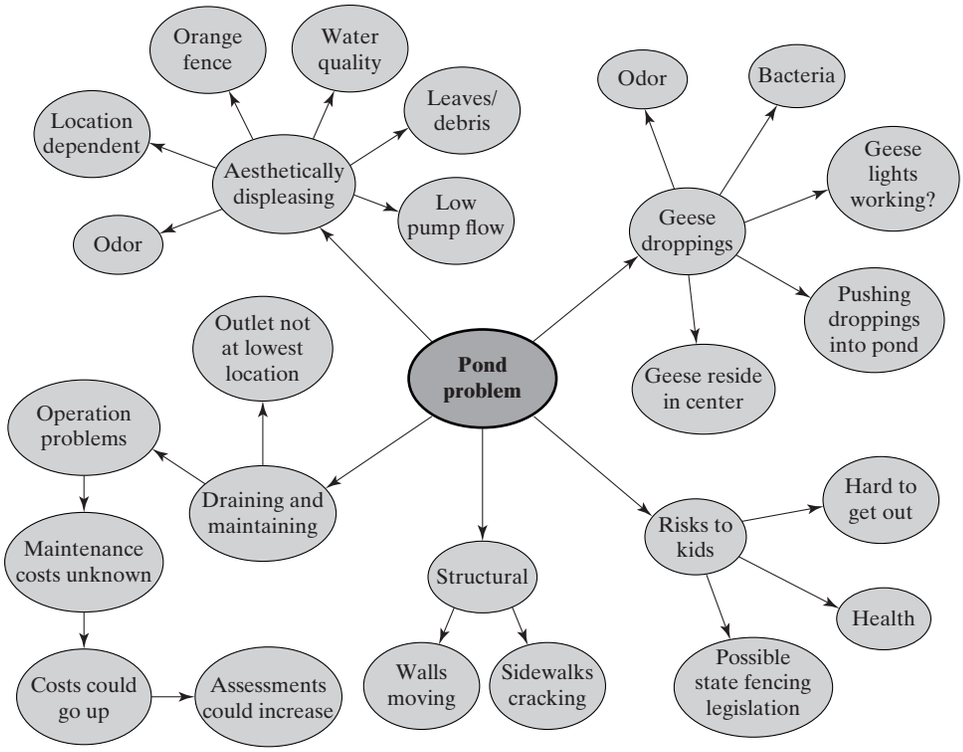


Figure 4.12
Preparing this mind map enabled a group to quickly define a problem and then focus on solving it.

a group gets started, a flood of ideas quickly appears. Very soon, a large mind map or cluster appears. To reiterate, while Mind Mapping, do not be judgmental of any suggestions. If someone suggests it, then it's mapped.

As shown in Figure 4.12, Mind Mapping identified five problem areas (aesthetics, geese, safety, structural, and draining/maintaining) and elaborated on each of them. As soon as the mind map was finished, the group turned to a discussion of possible solutions, one of which was implemented. The essence of this Mind Mapping example is that a problem well-defined is half-solved, and group Mind Mapping is an excellent problem-definition tool.

Mind Mapping software is available (e.g., see Prestpin 2011), but I suggest that you draw by hand, at least in your initial uses of this tool, so that you fully appreciate the method's potential. Hand drawing is uninhibited, enhances spontaneity, and more fully engages the right hemisphere of your brain (Arciszewski 2009). I have yet to see the need for Mind Mapping software for group use of Mind Mapping and am concerned with adding anything that detracts from the ability of the facilitator to read the audience, engage all members, and capitalize on the usual spontaneity of the process. However, you may want to experiment with software after initial manual efforts.

4.7.2 An Individual's Mind Map in Action

Several years ago, I wanted to create text and visuals for a presentation about cold calls as a marketing technique. Within engineering, making a cold call means that an engineer meets with a potential client or customer that does not know much about the engineer or his or her organization. The engineer's goal is to have the other person's organization eventually become a client or customer.

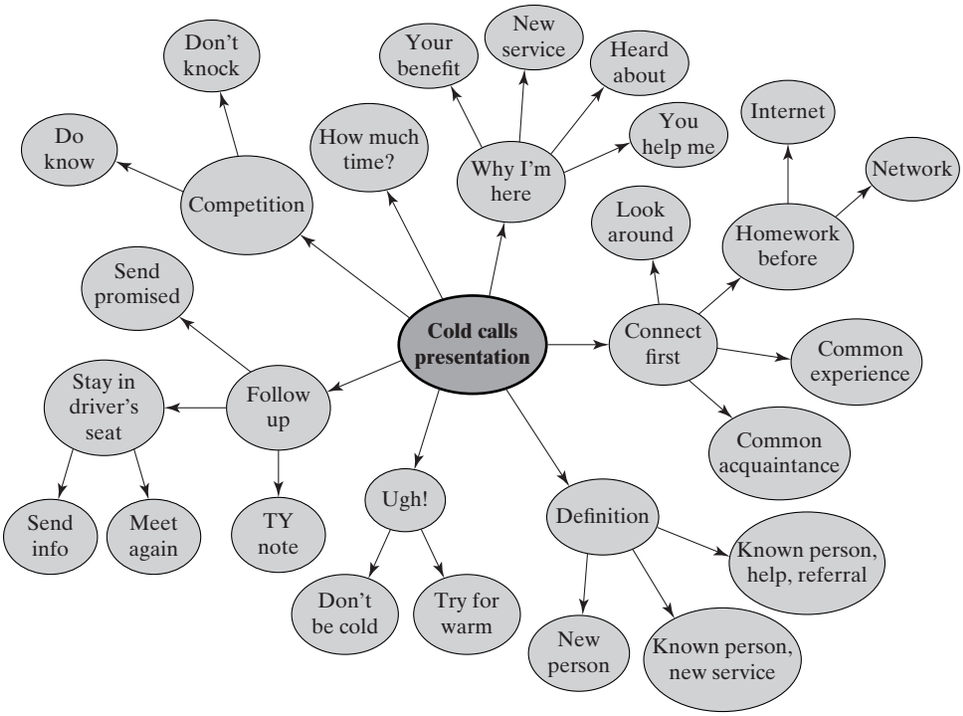


Figure 4.13
This mind map was used as the basis for creation of a cold calls presentation.

I needed to create an in-depth presentation about a topic that was somewhat new to me. Therefore, to get started, I prepared a mind map over a four-day period, devoting no more than a total of fifteen minutes to the effort. I subsequently took the hand-drawn version of the mind map and used it to make a neater version, which is shown in Figure 4.13. Remember, this mind map was created in only fifteen minutes over four days.

To get started, I wrote "Cold calls presentation" in the center of a piece of paper and then added whatever occurred to me in ovals. For example, my first thought was "Ugh!"—as in, "Who wants to make cold calls?" This led to the idea that maybe the calls didn't really have to be "cold" and instead could be somewhat "warm." Then I moved to defining who an engineer might be calling on and under what circumstances. After that, the mind map rapidly expanded and provided more than I needed to prepare my presentation.

Note that I prepared the mind map in spurts over a four-day period. If you do this, your conscious mind will prime your subconscious mind with the task at hand. Each time you return briefly to the Mind Mapping process, you are likely to discover new ideas and information to add to the map. Your subconscious mind will have been working behind the scenes for you.

I frequently use Mind Mapping in my work, either on an individual basis, as in the preceding example, or as a facilitator for a group. This tool has helped me and/or teams get started on reports, courses, proposals, presentations, and other tasks.

4.7.3 More Examples

As suggested by the two Mind Mapping examples, this tool can be used by an individual or a team in a variety of situations. As a consultant for a city utility studying whether or not to continue fluoridation of the public water supply, I facilitated two Mind Mapping exercises to help the city's Fluoride Commission imagine the many

and varied possible consequences of whatever they decided to do. One session assumed that they would recommend terminating fluoridation, and the other session assumed they would continue fluoridation. Both sessions quickly generated many ideas that proved useful in making their final recommendation, which was to continue fluoridation and revisit the issue in five years (Fluoride Commission 2014).

As additional examples, a team of graduate students used Mind Mapping to identify fourteen potential uses for highway median barriers, in addition to safety. Exercises 4.4 and 4.9 at the end of this chapter challenge you to do better. Another student team used Mind Mapping to list structural and nonstructural ways to quickly and temporarily flood-proof a highly vulnerable manufacturing plant that was threatened with flooding because of melting, unusually heavy watershed snow cover (Walesh 2011). That project is the basis for Exercise 4.12.

Former professor Arciszewski (2009) prepared a mind map showing ways to create the ambience needed for a successful engineering department at a university. The use of Mind Mapping in marketing is described with specific examples by Prestpin (2011). Gelb (2004) also offers Mind Mapping advice and presents examples of mind maps, including some using simple images instead of words.

4.7.4 Why Is Mind Mapping Effective?

Whether used individually or by a team, Mind Mapping is an effective means for generating ideas and information for the following reasons:

- Other than for the efforts of a possible facilitator, no preparation is required beyond choosing the topic and selecting participants, who should be very diverse, in keeping with the Medici Effect. This is not to say that participants could not be primed ahead of time to think about the IPO that they will address.
- Mind Mapping can be done quickly in real time (a half-hour to an hour per session for a group) by simply drawing on an individual's knowledge and experience or, better yet, on the combined knowledge and experiences of team members.
- Once the process starts, ideas and information flow, and each contribution, which is readily seen by all participants, tends to stimulate more contributions. Like Brainstorming, the process is all about generating unevaluated content for later consideration, but Mind Mapping is more visually stimulating.
- This process is nonlinear. It does not require one item to logically follow another in left-brain, step-by-step fashion. At any point, the mind map can grow up or down, left or right. Therefore, this tool also engages the right brain and many highly varied ideas are generated as a result. Stated differently, Mind Mapping supplements valuable left-brain abilities with equally valuable right-brain abilities.
- If Mind Mapping is conducted as a series of short episodes, the subconscious mind of one or more individuals will contribute additional information and ideas.

4.7.5 Uses of a Completed Mind Map

What do you do with the completed mind map—that is, the display of many connected, somewhat organized ideas and information? Consider the following possibilities, which are not necessarily in a preferred order, and mix and match them as appropriate:

- **Combine and distill:** Group ideas into categories and remove repetitious topics. When you do the former tempered by the latter, you will begin to sense that which is important to your group while revealing some completely new concepts, ideas, and directions.

- **Cherry-pick:** Select some ideas and pieces of information, recognizing that you may not be able to address all of them, and then prioritize and develop an action plan for the most viable ones.
- **Prepare and share an outline version:** Convert the mind map, or at least most of it, into a more organized outline. Send the outline to others, including the team that conducted the Mind Mapping, and ask for their thoughts. The outlined ideas and information will stimulate additional insights.
- **Conduct research:** Research selected topics and summarize the results.
- **Draft a document:** Use the Mind Mapping results to prepare and distribute a memorandum, report, or other document as needed, with supporting figures and tables. Request input.
- **Reconvene the original group:** Bring the Mind Mapping group back together, review post-Mind Mapping documents and activities (such as the aforementioned outline), discuss further, and decide on a course of action and implement it.
- **Develop more mind maps:** For example, the first mind map may have defined an engineering challenge, the second one could explore options to address it, and the third consider ways to implement the selected option.

4.7.6 Neuroscience Basis

Mind Mapping is informed by neuroscience partly because when this method is applied, the subconscious mind, or minds, are directed by the conscious mind or minds, become engaged, and begin to contribute ideas and information, especially if a follow-up session occurs.

Furthermore, this method's strong visual feature in the form of an expanding, highly visible cluster of ovals or other shapes stimulates activity in both hemispheres of participants.

4.7.7 Positive and Negative Features

The most positive aspect of Mind Mapping is its highly visual nature, which engages both of the brain's hemispheres, whether it is being applied by an individual or a team. The addition of an oval as a result of one person's suggestion stimulates others to think of more ovals. This is an especially important benefit for engineers, who tend to rely on left-brain thinking. Another benefit is that no preparation is required other than that of a possible facilitator. Considering the small amount of time required to apply it, Mind Mapping typically generates numerous and varied content.

The only significant negative feature of Mind Mapping is that optimum effectiveness when used by a group requires gathering a diverse group of individuals, consistent with the Medici Effect, and facilitating their interactions and contributions. Assembling such a group may be difficult, especially in hierarchical organizations in which important functions like decision making and long-range thinking have traditionally been reserved for a homogeneous set of individuals high in the organizational structure.

4.8 OHNO CIRCLE

Named after engineer Taiichi Ohno, an early innovator of the Toyota Production System, this method is "used to make deep observations of a process or scene with the goal of improving what you see" (Wilson 2011). The *Ohno Circle* differs from most of the other methods in that it is used only by an individual, not a group or

team. However, it may be used to enhance group or team performance, as discussed later in this section. Therefore, I include it in the set of methods intended to help you and your groups more creatively and innovatively address issues, solve problems, and pursue opportunities.

4.8.1 Description

"The story is that Mr. Ohno would have his engineers and managers who were new to a manufacturing facility draw a circle about two feet in diameter on the floor at a visually advantageous location in a factory. Then he would ask them to stand in the circle and observe what was going on for up to eight hours at a time" (Wilson 2011). They would share what they learned and any improvement ideas they may have. As suggested by Figure 4.14, one can imagine that the novice effect (Section 4.6.4) would naturally occur as novice engineers or managers ponder largely new processes and activities. Engaging the novice effect could lead to creative and innovative ideas.

We might argue that standing in a circle for many hours and observing is a waste of time. Instead, why not look at hard operations data—which assumes we have such data. However, "To Ohno, the big difference was that data was one step removed from the process, merely 'indicators' of what was going on," according to Liker (2004), a professor of industrial and operations engineering, who goes on to say, "What you want to do is verify the on-the-scene facts of the situation." Liker says that Ohno taught "the power of deep observation." This aligns with what is taught by Freehand Drawing, a whole-brain tool described in Section 7.4.

I realize you are not going to draw a circle on the floor and stand in it for eight hours or ask someone else to do so. However, how about taking thirty minutes, finding a quiet, unobtrusive place in one of your classes, laboratories, meetings, offices, or manufacturing plants, or at a construction site, and simply observing? Look and listen carefully, searching for wasteful or otherwise undesirable situations in categories such as the following (adapted from Wilson 2011):

- **Underutilized resources:** Capital, equipment, or personnel that are not being fully deployed or utilized
- **Excess motion:** Unnecessary movements of personnel, equipment, raw materials, and products that waste time and energy
- **Defects:** Production that repeatedly fails to meet standards and requires fixing

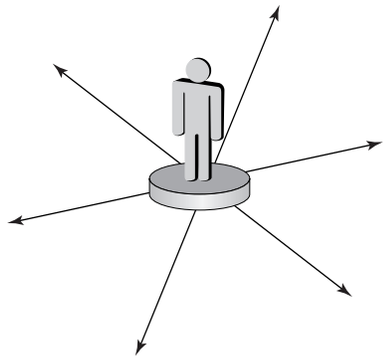


Figure 4.14
Ohno asked new personnel to stand in a circle, observe, and then share what they learned.

- **Excess inventory:** Retention and storage of parts, raw materials, and/or production not needed now
- **Non-value-added processing:** Performing work for which clients/owners/customers aren't willing to pay
- **Waiting:** Not having the materials, information, or resources at the right place or time
- **Safety and health hazards:** Objects to trip over, lack of eye protection, and similar risky situations

Search for ways to remove the deficiencies and make improvements in areas in which some of your suggested changes are likely to be creative and/or innovative. Document the improvement ideas and act on them.

Members of a team also could use the Ohno Circle. For example, assume that a diverse group of individuals has been formed and charged with finding ways to improve output from a production line in a manufacturing plant. An explanation of the Ohno Circle is part of the agenda at the team's first meeting. Prior to the second meeting, each person is asked to visit the production line alone and conduct a thirty- to sixty-minute Ohno Circle session. Observations are shared in writing and discussed at the group's second meeting and provide an informed basis for subsequent deliberations, some of which might include other methods described in this chapter and in Chapter 7.

4.8.2 Examples

While teaching one week of a graduate management-leadership course for civil engineers in Spain (Walesh 2011), I asked each student to select a situation, apply a modest thirty-minute version of the Ohno circle, and give me a written summary. Although students were limited by time and travel constraints, they selected a variety of everyday situations, observed them, and arrived at many and varied improvement suggestions. Examples of situations they observed and offered improvements on included team projects to be completed in class, passenger movement at a bus station, being productive in an engineering office, vehicle and pedestrian movement at an intersection, passenger movement on and off urban trains, and receiving service at a campus administrative office. These individual efforts generated some fresh and potentially useful ideas and illustrated the value of a modified version of Ohno's method.

Procter and Gamble's invention of the Swiffer floor cleaner includes Ohno Circle elements. In the 1980s, the company was looking for some new floor products and focusing on stronger detergents for use with cloth mops. After realizing the stronger detergents were not the answer, because they could damage the very floors they were trying to clean, the company's researchers decided, Ohno Circle style, to watch people clean floors.

They did this for several months, and one conclusion was that people devoted more time to cleaning mops than to cleaning floors. They also observed a cleaning person remove some spilled coffee grounds from the floor by using a moistened towel. These and other observations led to the conclusion that the long-reigning mop must be upgraded—and it was, by Swiffer, a floor-cleaning device with a disposable wet or dry cleaning surface (Lehrer 2012).

Innovation may seem obvious in retrospect, which is often the case. However, we don't create and innovate in retrospect. We need to start were we are, use tools such as the Ohno Circle, and move forward. What structure, facility, system, product,

or process might you or your team be able to improve if you simply took the time to really observe it?

4.8.3 Neuroscience Basis

Use of the Ohno Circle resonates with the research-based advice shared in Section 3.5: Our brains are much more productive when we focus—that is, stay on task for a meaningful period. The Ohno Circle capitalizes on vision, the most dominant of the six senses (Section 2.4.2). Applying this method also tends to cause conscious mind–subconscious mind interaction. That is, once problems have been identified by applying the Ohno Circle, the desire to solve them will be planted in the subconscious mind, the subsequent working of which could lead to breakthroughs.

4.8.4 Positive and Negative Features

The most positive feature of the Ohno Circle is the ease with which anyone can unilaterally apply it. Another plus is the ability to use the Ohno Circle as a prelude to productive work by a team charged with addressing a challenging IPO. That is, each team member could be asked to personally apply the Ohno Circle to some aspect of the team's charge and share his or her observations with the team. The only possibly negative aspect of the method is the potentially unpleasant experience of staying in one place for an extended period while diligently seeing, listening, and thinking—but on second thought, isn't that what smart people ought to do, at least every now and then?

4.9 STREAM OF CONSCIOUSNESS WRITING

This method, like the Ohno Circle, is intended primarily for personal use, although members of a group could each do it for a predetermined question or topic and then share key aspects of their results. A group version exists and will be discussed shortly. Innovator Gelb (2004) describes *Stream of Consciousness Writing* as a "marvelous tool for plumbing the depths of your questions" and, I would add, any topic that interests or challenges you. He suggests that this tool can lead to insights and creative/innovative ideas because it overrides the "habitual, superficial aspects of your thought processes."

4.9.1 Individual Application

Stream of Consciousness Writing, which is also called *Brain Writing* (Fogler, LeBlanc, and Rizzo 2014), is the simplest method in this chapter and takes the least amount of time to apply. The following description of individual application is based on suggestions offered by Gelb (2004).

Select an issue that you want to address, a problem you need to solve, an opportunity you are considering, a question you are trying to answer, or a topic that you want to learn more about. Find a location where you will not be interrupted. With pen or pencil and paper or at your computer, write without stopping—without lifting your pen or pencil from the paper or your fingers off the keyboard—for ten minutes. Write whatever enters your mind and do not edit. Yes, some of what you write will be foolishness, but every now and then a fresh idea will emerge as you write; even as you continue to write, you may ask yourself, "Where did that come from?" Arciszewski (2009), a former engineering professor, had this to say about his teaching experience with this method: "The results of this exercise are usually amazing since it forces the student to think with both hemispheres of his/her brain."

When you are finished, read out loud what you have written and highlight words and ideas that seem insightful, creative and/or innovative, and potentially useful. Follow up with investigation and other actions as appropriate.

PERSONAL: AWKWARD AND REWARDING

During my first use of Stream of Consciousness Writing, which I tried because I was considering including the method in this book, I selected a business question that had been on my mind for some time. As soon as I started, I felt awkward, partly because I typically try to think widely and deeply when I write, which involves stopping, contemplating, occasionally walking around, and sometimes taking a break. However, I was quickly able to put aside my usual practices, disengage my internal editor, and simply write whatever popped into my mind. Some of it was foolishness placed on the paper so that I could dutifully keep writing. However, after the ten minutes of writing, I reviewed what I had written. Amid the debris, I found some fresh insights. Try Stream of Consciousness Writing: Your cost and risks are low, and the probability of benefits is high.

4.9.2 Group Application

Stream of Consciousness Writing can also be applied in a mostly silent mode by a group or team assisted by a facilitator as follows (Dhillon 2006):

1. Ask participants to sit around a table and give each person one sheet of paper.
2. Describe the issue to be resolved, the problem to be solved, or the opportunity to be pursued and a particular aspect of it, such as defining the issue or proposing solutions to the problem. Once the IPO is understood, request silence while participants work.
3. Encourage each person to write whatever comes to mind for one to several minutes—this is the time to be very freewheeling and not practical.
4. Ask each participant to pass their sheet of paper to the person next to them, or to encourage anonymity, mix the sheets up in the center of the table and have each person take one sheet, but not his or her own.
5. Repeat Steps 3 and 4 until written ideas diminish.
6. Gather all of the pages, post or summarize them, and engage the previously silent participants in evaluating the results. If group Stream of Consciousness Writing was used to define an IPO, it could be used again, now or later, to enable subconscious thinking and to generate resolution options. Multivoting (Section 4.4.2) might be used to rank the resulting options.

4.9.3 Neuroscience Basis

As noted by Arciszewski (2009), Stream of Consciousness Writing seems to draw on both sides of the brain. Perhaps this is because we are compelled to write for ten minutes when the method is applied individually (or for less time with the group process) no matter what happens. This encourages us to draw on all of our cognitive resources. According to Gelb (2004), if you persevere for the required period of continuous writing, "you'll eventually open a window through which your intuitive intelligence will shine." *Intuitive* means that you will engage your right hemisphere to supplement the left one. If the focused writing, whether in the individual

mode or the group mode, is intentionally interrupted, then new ideas are likely to be generated when the effort resumes.

Recall the Section 2.12 discussion of your brain's negativity bias. As explained there, because of evolution, we are still subject to our ancestors' need to see danger or potential danger in a variety of common daily circumstances and to act defensively. The pressure attendant to Stream of Consciousness Writing may help you temporarily set aside the limiting thinking characteristic of negativity bias and reveal some heretofore unseen possibilities in your student life, professional practice, or personal life.

4.9.4 Positive and Negative Features

Clearly, the most positive aspect of Stream of Consciousness Writing is the ease with which you can try it. When used individually, less than a minute of your time is required to understand the individual version of the method, ten minutes to use it initially, and five minutes to review and think about the results. The return on that small time investment will probably be some fresh insights and maybe some creative/innovative ideas. Other than possible temporary discomfort while performing the writing, there are no negatives. The group approach might produce many ideas because it combines the effect of each participant thinking deeply and broadly about the topic, as in the individual version, with the stimulation of seeing the ideas of others.

4.10 STRENGTHS-WEAKNESSES-OPPORTUNITIES-THREATS

Although this method can be used by an individual, it's much more effective when applied by a group. *Strengths-Weaknesses-Opportunities-Threats* (SWOT) enables a group to thoroughly define and analyze essentially all aspects of an issue to be resolved, a problem to be solved, or an opportunity to be pursued.

4.10.1 Description

As is often the case with the use of the whole-brain methods described in this book, SWOT begins by having a facilitator assemble a heterogeneous group. Provide background information and pose the IPO that is to be thoroughly defined and analyzed prior to exploring resolution options.

Assume the IPO is a problem: a poorly performing service line in an engineering consulting firm. Within the engineering environment, the problem could also be a poorly performing research and development department, academic department at a university, design team, or manufacturing line. Create a readily seen matrix, like the one in Figure 4.15, in which the first column contains various elements or aspects of the problem. The remaining four columns represent the strengths, weaknesses, opportunities, and threats associated with each of those elements.

Start with the first row (Our personnel). In the Strength column, a group member suggests writing "Bill is an expert"; for the Weaknesses column, someone offers, "Bill does not listen to clients or colleagues." The Opportunities column entry might be "Maria contacted us concerning possible employment, and she is known to have great client communication skills." A Threats column entry might be "We will lose even more clients if our personnel continue to miscommunicate, mostly because of Bill." Stimulated by all of this, more short statements are likely to be suggested for the Our personnel row.

Then, the group moves on to the other rows. By the time the table is completed, at least in a first pass, many highly varied aspects of the poorly performing service line issue are now displayed, representing the collective view (at least the

Figure 4.15
The SWOT method generates a thorough understanding of a challenging issue, problem, or opportunity.

Element	S	W	O	T
Our personnel				
Our tools				
Existing clients				
Potential clients				
Regulatory environment				
Financing available				
	Internal		External	

initial collective view) of many diverse individuals. If the group temporarily adjourns and then gathers again in several days or so to resume the SWOT, be assured that many more contributions will be offered because of the workings of subconscious minds during the interval. Based on what is collectively learned as a result of the SWOT analysis, use other tools to generate ideas for how to solve the now well-defined problem, select a course of action, and develop an action plan.

As a student, you could readily imagine a group using SWOT to analyze why your senior project team is not productive, why the student chapter of your engineering professional society is struggling, or why your Greek organization has a poor reputation on campus. SWOT would also be useful, applied individually, for analyzing the first session of your multi-session co-op program or the first part of your job or graduate school search.

4.10.2 Examples

In the process of serving my clients, I have often used SWOT to assess situations and generate improvement ideas. In one case, office staff at a city's water utility participated in SWOT with the goal of improving their effectiveness and efficiency. We identified the following topics and determined strengths, weaknesses, opportunities, and threats for each: working space/layout, customer service, computer support, working with other units, communication, and personal recognition/reward. The result was a current and comprehensive snapshot of the office's operations, which led to many ideas for improvement.

I facilitated SWOT sessions with technical staff at the aforementioned water utility, with leaders of a wastewater district, and with managers of public festival grounds. The results were always the same: active participation by essentially everyone, a broader and deeper understanding of the situation, and generation of ideas for improvement, some of which were creative/innovative.

As suggested by the preceding examples, SWOT can be used in a variety of ways. For example, Milosevic (2010) describes using SWOT to determine how investors and contractors view a particular construction project. You can use SWOT as part of group efforts to improve your sorority or fraternity, campus organization, or senior project team. Later, you will find applications in engineering practice, some within your organization, and some involving your clients or customers. SWOT enables a group to quickly obtain a snapshot of its situation and use it as the basis for beginning to generate ideas, using other tools for making improvements.

4.10.3 Neuroscience Basis

SWOT connects to our growing neuroscience knowledge in four ways. First, the highly visual nature of the evolving matrix will stimulate both hemispheres of

participants. Second, if a group applies SWOT to the same IPO in two or more sessions, the analysis will benefit from the conscious–subconscious mind interactions of each of the participants. Third, some group members may begin the SWOT effort with a narrow view of the IPO, possibly because of their strong left-brain orientations. However, their views will change and become more informed as they consider the input of others, as manifested by the many items in the first column of the rapidly developing table and the four aspects of each in the other four columns. Fourth and finally, the need to address both positives and negatives (Section 4.10.4) stimulates thinking, including emotional aspects, which tends to further engage the right hemisphere.

4.10.4 Positive and Negative Features

One positive aspect of SWOT is that it cannot degenerate into a complaining or whining session, which sometimes happens when troublesome issues or problems are discussed. While weaknesses and threats are unpleasant or negative, strengths and opportunities are uplifting and therefore positive. Furthermore, with respect to the group's potential to act and as shown at the bottom of Figure 4.15, although opportunities and threats are external and largely out of the group's control, strengths and weaknesses are internal and can be addressed by the group.

A possible negative aspect of SWOT is its seemingly somewhat restrictive structure. Once the participants begin the process, some may be inhibited or frustrated by the well-defined matrix. This potential obstacle can be easily offset by encouraging the group to be open to adding rows (elements or aspects of the IPO) to the matrix and to be willing to revisit any area within the matrix to add or modify content.

4.11 TAKING A BREAK

As a student, whether working individually or within a group, you're sometimes bogged down when intensely studying, researching, experimenting, analyzing, designing, writing, or engaging in some other challenging endeavor. You hit a wall, draw a blank, or experience writer's block. Similar frustrating experiences occur in professional practice. When this happens, whether you are a student or practitioner, take a break!

4.11.1 Description

Most of us welcome the invitation to take a break or the personal inclination to do so. However, we may also feel some guilt because walking away from the task at hand may conjure up thoughts of procrastination or laziness. Don't go there! Why? Because *Taking a Break*—that is, changing from one type of activity to another—stimulates creativity and innovation. This is especially true when transitioning from intense work to leisure, exercise, or a hobby.

Professor May (1976) tells the story of Einstein asking a friend, "Why is it I get my best ideas in the morning while shaving?" The friend's answer was, "Often the mind needs the relaxation of inner controls—needs to be freed in reverie or daydreaming—for the unaccustomed ideas to emerge." More specifically, according to Restak (2009), studies indicate that eureka moments tend to involve a shift in brain activity from the left to the right hemisphere. That shift tends to occur when we *power-down*, to use his term—that is, when we take a break or sleep.

PERSONAL: CHANGING GEARS TO MOVE AHEAD

One day, first thing in the morning, I began work on a book proposal for submission to a publisher. After about two hours, I had a good start, including an outline and some text. However, I began to bog down and also get hungry. I biked to a nearby restaurant and, while enjoying a light breakfast, three proposal-related ideas popped into my head. I wrote about them on the backside of a paper placemat, folded it, and tucked it into my pocket. I then began a ten-mile bike ride, during which I stopped three times to briefly jot down more ideas that appeared out of the blue. These specific situations are typical of many similar creative experiences I've enjoyed over the years that were stimulated by intensely working on a project and then changing gears. By the way, the proposal was accepted, and the book was published (Walesh 2000a).

May (1976) recognizes that what he refers to as "the insight [that] comes at a moment of transition between work and relaxation" is common. However, and this is critical to optimizing Taking a Break, he strongly suggests that these vivid breakthroughs of the subconscious mind to the conscious mind are preceded by "intense, conscious work." Think about an instance when an idea suddenly appeared to you out of the blue, perhaps during relaxation or exercise. Although the idea appeared to come from nowhere at the time, personal reflection is likely to reveal that it was preceded by one or more sessions of focused effort.

As illustrated in Figure 4.16, your conscious mind must make an intense effort before resting and (hopefully) allowing your subconscious mind to share creative and innovative ideas. Gelb (2004) says this about conscious mind–subconscious mind interplay: "Without periods of intense, focused work, there is nothing to be incubated." We cannot relax our way into creativity and innovation. As noted by engineering professor Cross (1952), "Hard work has a surprising way of paying unexpected dividends through later inspirations." However, we need to know when to stop and take a break.

Consider one specific way to leverage that hard work. Recall (as explained in Sections 2.9.2 and 2.9.3) that your conscious mind ceases operations while you are sleeping. In contrast, your 24-7 subconscious mind continues to function. Therefore, before retiring, summarize in writing the challenge you are facing and the hard work you have done to meet that challenge. Then, apply Taking a Break—that is, sleep. You may wake with some fresh ideas as a result of the work done by your subconscious mind while you slept.

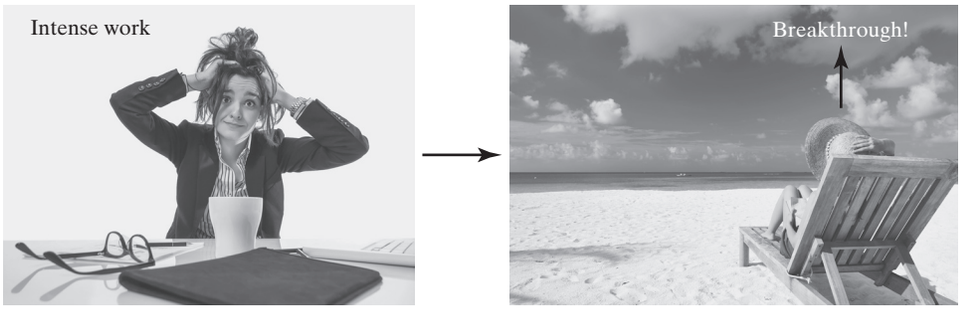


Figure 4.16
Creative/innovative breakthroughs from the subconscious mind are preceded by intense conscious effort.
(Doble.d/Fotolia; Haveseen/Fotolia)

4.11.2 Example: Bar Code

Reflecting on beaches, breakthroughs, and the work that precedes breakthroughs, consider the bar code story. In 1948, while an electrical engineering graduate student at Drexel Institute of Technology, Bernard Silver learned that a food store chain wanted to speed up the checkout process at its stores. He partnered with Norman Woodland, a friend and fellow graduate student, and they started to work on a system. Their first working model used fluorescent ink, but it faded and was expensive. This was the beginning of what would prove to be persistent effort with a breakthrough ending.

Eventually, mechanical engineer Woodland moved to Florida, near the beach, and continued to work on the project, now inspired by Morse code, which he had learned as a Boy Scout. He began to think about dots and dashes. One day at the beach during the winter of 1948–1949, while lying back in a beach chair, he stretched out a hand, put it in the sand, and pulled it back. He looked at his finger marks in the sand, saw lines of varying width, and this led to the bar code concept.

Silver and Woodland received a patent in 1952 for a "Classifying Apparatus and Method." The patent included the printing patterns and the mechanical and electronic systems needed to read the code. Philco bought the patent from Silver and Woodland for $15,000 in 1952, then RCA purchased it in the 1960s, a decade after the patent was issued. The missing element was the laser, which eventually enabled effective reading of bar codes.

On June 26, 1974, a ten-pack of Wrigley's Juicy Fruit gum was scanned with a device made by the National Cash Register Company (now NCR) at Marsh's Supermarket in Troy, Ohio. That package of gum is on display at the Smithsonian Institution's National Museum of American History. The first use of the bar code occurred twenty-six years after the day in 1948 when Silver conceived of it.

Astounding success followed: By 1980, 8,000 stores per year were converting to bar codes. Benefits to stores included a 1 to 2 percent decrease in operating costs and a 10 to 12 percent increase in sales that never dropped off. Of course, now we see bar codes all over (Adams 2014; Boehler 2012; Fox 2012).

Let's reflect on the Taking a Break tool in light of the bar code story. The bar code inspiration occurred while Woodland was relaxing at the beach and applying what we are calling Taking a Break from his roughly one-year effort to speed up the checkout process at stores. That insight was followed by an approximately twenty-five-year implementation period.

4.11.3 Example: Student Work

As a student, do you sometimes encounter a proverbial brick wall when trying to solve a difficult assigned exercise, understand a textbook's description of a topic, or make progress on your research project? Instead of trying to break through the wall macho style, apply Taking a Break and benefit from the productive interplay between your conscious and subconscious minds, between explicitly thinking about your mental challenge and letting it incubate in your other mind. For example, consciously and intensely work on the exercise, text, or research for about fifteen to thirty minutes, then set it aside and focus on something else.

Be confident that your subconscious mind will take over the task and provide you with new insights, either as an out-of-the-blue "aha!" moment or as a revelation when you consciously resume work on completing the exercise, understanding the

text, or moving forward on your research. Engineering professor Oakley refers to student use of the conscious mind–subconscious mind interaction as the focused mode–diffused mode process (Oakley 2014).

4.11.4 Neuroscience Basis

Taking a Break is successful because it combines consciously focusing on a topic for a constructive period of time (one way to more productively use our brains, as explained in Section 3.5) with giving the subconscious mind an opportunity to function (as discussed in Section 2.9). The focused conscious effort primes the subconscious mind by giving it an increasingly well-defined task to work on. We may consciously try to engage both our left and right brains and do it with some success, but our subconscious minds enable us to draw on all of our cognitive resources.

4.11.5 Positive and Negative Features

One positive feature of Taking a Break is that its use is natural, at least in a rough way. When faced with a challenging IPO whose resolution is important to us, we naturally work intensely at it, while taking breaks to do other work-related tasks or to enjoy other activities. However, effective use of Taking a Break requires knowing when to back off—to temporarily walk away from the intense effort—and then having the confidence that your subconscious mind will eventually make one or more major contributions to helping resolve the IPO. Another positive aspect of this method is that, like most of the methods in this book, it can be used by an individual and by a team.

A possible negative feature of Taking a Break is that the conscious thinking efforts, whether done individually or by a team, will lack intensity. This denies the subconscious mind the breadth and depth of concepts, ideas, and information needed to perform its cognitive functions. Another negative is that an impatient person may not stick with the process long enough to effectively engage his or her subconscious mind. Consider Albert Einstein's view: "It's not that I'm so smart, it's just that I stay with problems longer." I might add that extra time allows the whole brain—left and right, conscious and subconscious—to contribute.

4.12 WHAT IF?

When faced with a challenging IPO, consider asking "*What if?*" in a way that temporarily and radically changes your point of view (Nierenberg 1982; Tice 2011). As a way of fully engaging both hemispheres, briefly view the challenge from totally different vantage points; for the time being, remove conventional constraints. As a result, you may literally or metaphorically see new realistic possibilities.

4.12.1 Description

Let's say you and your team are focused on an especially challenging IPO. Maybe it's a complex design, diagnosing a failed facility, dealing with a troublesome manufacturing line, or a vexing personnel problem. Up to now, you have adopted an up-close, frontal perspective. This is the time to ask, "What if?":

- What if, as illustrated in Figure 4.17, we were to metaphorically take a bird's-eye view? Look at it from just above, a worm's-eye view? Look at the challenge from the bottom? Or from a thirty thousand-foot view? Look at it from way above to see the bigger picture—the wider context?

Figure 4.17
What if we looked at our challenge with a new point of view, such as from just above, from below, or from way above?
(Erni/Fotolia; Fotomaster/Fotolia; Arturas kerdokas/Fotolia)

- What if funds were unlimited? They never are, but our thinking is sometimes unnecessarily constrained by limited financial resources.
- What if we had to build a bicycle out of cardboard?
- What if all subsurface conditions at a proposed construction site were known?
- What if, although we always perform some process as a series of steps (as shown at the top of Figure 4.18), we changed the order, performed some steps in parallel, and/or omitted low or no value steps?
- What if we just learned that a well-known consulting firm will enter our regional marketing area in three months?
- What if we had to install the new manufacturing line in one week? Yes, that is impossible, but what might trying to do it make us think of that would never have entered our minds?

What If mind sets, as foolish as most may be, enable you or members of your group to temporarily think beyond constraints and obstacles and maybe see new possibilities and find creative/innovative ways to overcome those impediments. An initial outlandish What If might be a stepping stone to a more reasonable What If.

For example, a Netherland city had a problem with out-of-control refuse because people were not using trash cans. An initial thought was to wonder, what if

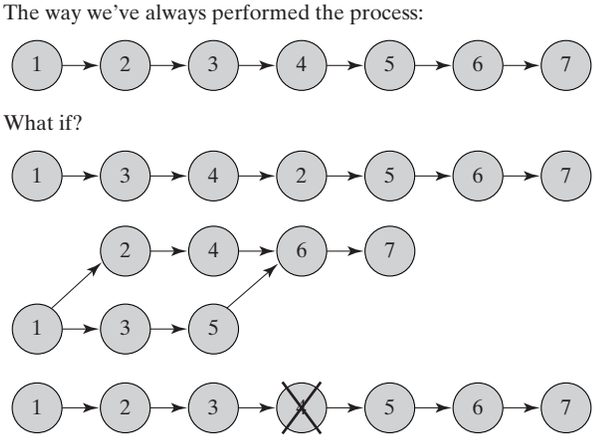


Figure 4.18
What if we changed the order of steps in a process, performed some steps in parallel, and/or omitted low or no value steps?

the city installed electronic sensing devices in trash containers that would use a coin mechanism to pay people when they put trash in the container? That unusual idea might solve the refuse problem but could bankrupt the city because of the cost of installing and maintaining the system, including keeping the containers stocked with cash. The flawed idea lead to further consideration of providing rewards for using trash containers. Researchers asked, what if we rewarded people for using trash containers by developing a sensor that would sense when refuse was added and activated an audio system that would play a joke, with the jokes being frequently changed? It worked (von Oech 1990)!

As another example of how an initial What If can be a stepping zone to a better one, consider a dog food company for which researchers explored the idea of putting nondigestible flower seeds and fertilizer in dog food. The dogs would be the means by which flowers would be planted and fertilized around a neighborhood. That What If was rejected, but it lead to the idea of putting grass seed in cattle feed as a means of reseeding range lands, which worked (von Oech 1990).

4.12.2 Example: Taco Bell Restaurant

Recall one of the preceding What If statements: "What if we had to install the new manufacturing line in one week?" The Taco Bell restaurant company provides an example of the benefits of looking at a similar seemingly extreme What If statement. The six-day disastrous August 1965 riots in the Watts area of Los Angeles, California, resulted in thirty-four deaths, over one thousand injuries, four thousand arrests, and forty million dollars in property damage, which included one Taco Bell restaurant (Civil Rights Digital Library 2014).

The Taco Bell company vowed a Watts comeback, and to emphasize its commitment, the firm announced that it would rebuild the restaurant over a forty-eight-hour period: This is the Taco Bell What If. After careful design and planning, the restaurant was prepared to rebuild as promised. Taco Bell placed a concrete slab; marshaled personnel, materials, and equipment on the site; and simultaneously started construction and a large on-site clock. The next forty-eight hours of carefully planned construction were recorded on video (Taco Bell, n.d.). Within just under forty-eight hours, the new restaurant started serving tacos. The company's application of What If yielded two benefits:

- Taco Bell earned positive publicity.
- The restaurant learned how to reduce construction time, which back then was fifty to seventy-five days. Building future restaurants in forty-eight hours would not be economically feasible, but the business learned enough about materials, personnel, and process as a result of the forty-eight-hour challenge to reduce the cost of more conventional construction by 20 to 50 percent. At the time, Taco Bell was building three hundred stores per year, which translated into major, ongoing cost savings for the company.

4.12.3 Example: Street Storage of Storm Water

In the 1980s, the 8.6 square mile community of Skokie, Illinois, a suburb north of and contiguous with Chicago, faced increasingly frequent and widespread basement flooding caused by backup of combined sewers during rainfall events. At the time, sewer separation was a common solution, but applying this approach in Skokie would mean converting the existing combined sewers to sanitary sewers and constructing new storm sewers at a cost of $203 million, in 1999 dollars. That level of funding was not available; a much less costly approach was needed.

Accordingly, engineers collectively and innovatively applied What If. More specifically, they asked, "What if we were to design and construct a system that would temporarily store much of the storm water on the streets throughout the entire community and then slowly release it into the combined sewers so that they would not surcharge?" This would solve the basement flooding problem.

Although unusual, this new idea of community-wide use of short-term street storage was attractive for three reasons: First, it might cost much less than traditional approaches. Second, it could counter the limited availability of off-street surface storage sites given the dense urban development. Third, temporary storage of storm water before it mixed with sewage addressed the cause of the problem—that is, out-of-control storm water. The concept of temporarily storing storm water on streets in a controlled manner to mitigate uncontrolled basement and surface flooding is illustrated in Figure 4.19.

The project began in 1982 and moved through discussion, public education and involvement, research, establishment of design criteria, preliminary design, hydrologic/hydraulic modeling, pilot testing, and final design. The system was built in phases from 1983 to 1999. The street storage system required constructing or installing 871 street berms like those shown in Figure 4.20, twenty-nine hundred flow regulators in catch basins as shown in Figure 4.21, ten off-street surface storage facilities, eighty-three subsurface storage facilities, sixty-four thousand feet of storm sewer, and twenty-nine thousand feet of combined sewer.

Much of the storm water storage and conveyance occurred on the streets in a controlled manner, as suggested by Figure 4.22, with supplemental storage provided off-street and beneath streets. The cost of the project was $78 million in 1999, or 38 percent of the cost of sewer separation (Walesh 2000b; Walesh and Carr 1999).

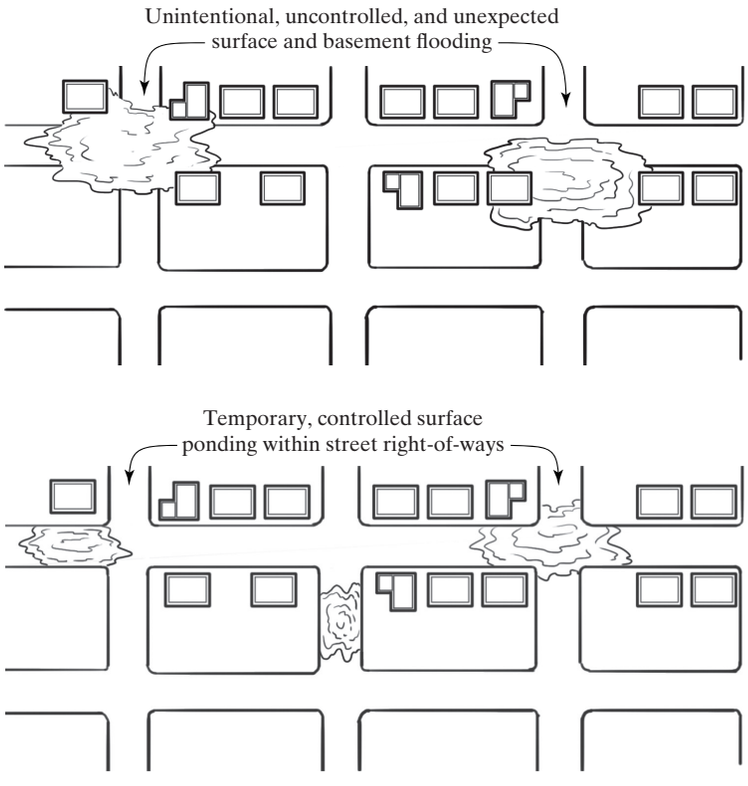
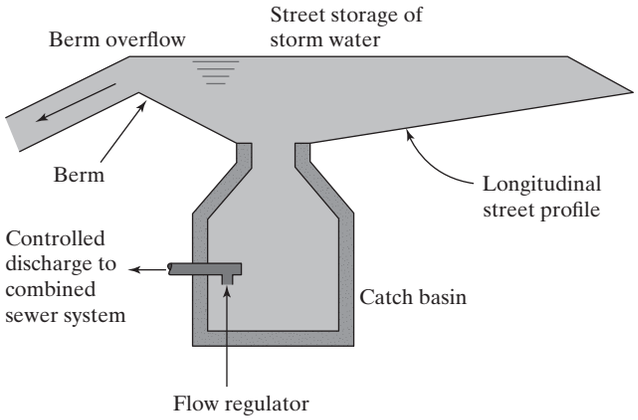


Figure 4.19
The street storage approach uses temporary ponding of storm water to mitigate uncontrolled basement and surface flooding.

Figure 4.20
Mild berms constructed across streets and intersections help to temporarily store storm water on the streets.
(Stuart Walesh)



Note: Not to scale and great vertical exaggeration

Figure 4.21
A flow regulator in a catch basin and a berm function as the outlet works of a temporary street storage facility.
Source: Adapted from Walesh 2000b.

Figure 4.22
Controlled temporary flooding of streets prevents uncontrolled basement flooding.
(Wckiw/Fotolia)

Because the project was innovative, the US Environmental Protection Agency commissioned a post-project study (Walesh 2000b). This investigation addressed a range of technical and nontechnical factors and concluded that the innovative system

- greatly reduced flooding;
- helped to raise the community's credit rating, adding $40 thousand to the average value of houses;
- avoided large increases in property taxes because of the phasing;
- resulted in only two claims and no litigation;
- increased system operation and maintenance, which was expected; and
- caused minimal pavement icing and left no evidence of pavement deterioration, both of which had been early concerns.

4.12.4 Example: Combining Features while Retaining Functions

Another application of What If is to look at one or more useful devices and ask, "What if we simplify them by combining features without compromising desired functions?" Benefits could include improved function and reduced cost. Reusing a proven design as a part of a new structure, facility, system, product, or process can significantly reduce design, manufacturing, construction, and other costs. Sometimes, repurposing is better than creating something new (Pisasale 2014).

Micropiles

After WWII, buildings and monuments across Europe were damaged. In response during the 1950s, the Italian civil engineer Fernando Lizzi invented micropiles as a means of underpinning war-damaged structures and monuments. These ingenious devices "develop their axial capacity primarily through the bond between the grout and soil or rock in the bonded zone of the pile." Advantages of these innovative underpinning devices include the following (Bennett 2010):

- Appropriate in low-headroom situations
- Low vibration and thus suitable for work close to existing structures
- "Can be installed in soil and rock conditions where the use of other conventional deep foundation systems is not a reasonable alternative, such as Karst topography or where modest subsurface obstructions or boulders are present"
- Applicable below the water table where other foundation systems are prohibited because of caving

Of relevance to this section on combining features is the observation that the drill used to form the hole within which the micropile will be formed becomes the means of inserting grout and then becomes the piling (Bennett 2010; Bennett and Hothem 2010).

Other Combining Examples

Some fast food restaurants provide customers with a spork, a plastic utensil that is a combination of a spoon and a fork (Figure 4.23). On my car, the usual gas filler access door and the gas filler screw-on cap are combined into one easier-to-use and presumably less costly unit (Figure 4.24). The creation of the integrated circuit, which is described in Section 6.3.3, nicely illustrates combining features in that now all circuit components can be made of a single material and interconnected to form a complete circuit. Another combining functions example is the Gratefish, a storm water system grate in the shape of a fish that replaces the conventional grate and the signage warning that the storm water system discharges into local surface waters (Neumeier 2014).

Figure 4.23
This utensil combines a plastic spoon and a plastic fork.
(Stuart Walesh)

Think about objects you use; that structure, facility, system, product, or process building you are designing; and the tasks you routinely and frequently perform. Ask yourself, "What if I could retain desired functions while combining features, simplifying, and reducing costs?"

4.12.5 Example: The Panama Canal

In the late nineteenth century, the French tried but failed to construct a sea-level, interoceanic canal across the Isthmus of Panama. They were defeated by a combination of yellow fever, malaria, other deadly tropical diseases, and the challenge of having to excavate an unprecedented amount of earth and rock.

The United States purchased the assets of the French canal company and started work on a sea-level canal in 1903. The sea-level approach was soon abandoned in favor of building a dam on the Chagres River to create a lake, now called Gatun Lake, on the isthmus. As shown in Figure 4.25, the lake would be connected to the

Figure 4.24
The usual gas filler access door and the usual gas filler cap are combined into one unit.
(Stuart Walesh)

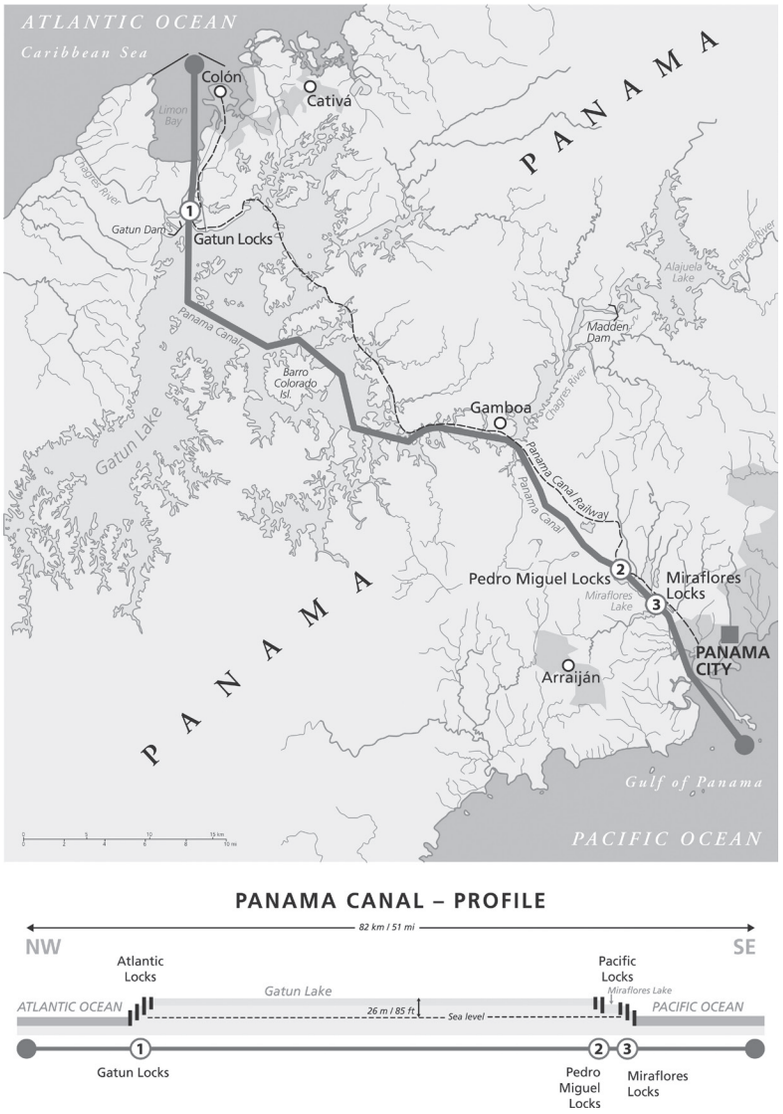


Figure 4.25
The original sea-level method for constructing the Panama Canal was replaced with this lake and locks approach.
(Peter Hermes Furian/Fotolia)

Pacific Ocean by one series of descending locks and to the Caribbean Sea by another series of descending locks. Gatun Lake would provide water by gravity to operate the locks. This approach to the fifty-one-mile project greatly reduced the amount of material to be excavated and hauled away (Brown 2014).

The Panama Canal project was facing many challenges when engineer Stevens took over its leadership in 1905, bringing with him many engineering achievements, especially in railroading. "The question was whether the entire American venture in Panama could be rescued from humiliating defeat" and lead away from failure such as the French experienced. The lock system approach was finalized early in Stevens' tenure, and then he addressed many challenges (McCullough 1977).

One challenge, as already noted, was figuring out how to excavate and haul rock and earth. Stevens' French and American predecessors saw the project as an excavation project, but he took a What If approach and viewed it as a railroad project. He saw the cut workers were excavating across part of the isthmus as a

"gigantic railroad pass" (Fredrich 1989). Although excavating was a challenge, hauling the excavated rock and earth to either coast or to wherever fill was needed, such as the site of the dam that would form the lake, was a much bigger challenge. Stevens instituted what was known as the Railroad Era, during which his objective was "to create a system of dirt trains that would function like a colossal conveyor belt, rolling endlessly beside steam shovels working at several levels at once" (McCullough 1977).

"The ultimate goal of the excavation operations was to keep an empty muck car next to the steam shovel every second of every work shift" (Rogers 2014), as shown in Figure 4.26. Doing this required the creation of a track-mounted machine that could quickly pick up and move a section of rail with ties attached so that rail cars could always be close to the excavating machines. "Building the Panama Canal was, among other things, one of the greatest of all triumphs in American railroad engineering." The construction of the canal continued under the leadership of a series of engineers, with the canal opening quietly in 1914 (McCullough 1977).

In relating this story of engineering creativity and innovation, I am not saying that Stevens explicitly applied What If shortly after his arrival in the isthmus.

Figure 4.26
A steam shovel loads excavated material onto railroad cars as part of the railroad approach to constructing the Panama Canal.
(Everett Historical/Shutterstock)

However, his radical and successful change in focus from an excavation project to a railroad project and the attendant developments and actions exemplifies What If. A lesson learned from Stevens is that when we find ourselves in the position of having to clean up, fix, or finish someone else's project (and most of us will be in that position at some point), we should assess the situation and start thinking, "What if?"

4.12.6 STC: Another Way to Think about What If

Altshuller (1996), the Russian originator of the Theory of Inventive Problem Solving (Section 7.9), refers to the Size-Time-Cost (STC) operator. By radically varying these three parameters one at a time when taking on an IPO, he says that "we are deliberately complicating the problem and, at the same time, we are searching for a simplified solution." He notes that STC is a "tool for your imagination" and is intended to "break up our psychological inertia, which blocks our thinking." The Taco Bell restaurant story is in effect an example of using the Time part of STC. The company was motivated to be innovative by thinking about drastically reducing the normal, multiple-month construction time to a seemingly impossible two days.

Altshuller describes an example in which a pipeline was to be designed so that at any time it could be transmitting, in series at the same time, two or more different liquid petroleum products. The products would need to be separated to prevent mixing, and the separator would need to go through the pumps. The Size part of STC was used: The designers started to think of a separator so small that it would pass through the pumps. How could that be? They thought about tennis balls, smaller balls, pellets, and finally molecules: Molecules would pass through the pump.

Then the question became, molecules of what? The answer was to form a separator out of aqua ammonia because it was nonorganic and therefore would not dissolve in petroleum products; it was safe and inexpensive. As explained by Altshuller, "During transportation, this separator will partially mix with the petroleum . . . At the final station, the ammonia will turn into gas and evaporate," leaving just the desired petroleum product.

4.12.7 Neuroscience Basis

The What If method moves you away from overreliance on your left brain toward engaging your right brain because it temporarily sets aside typical logical constraints provided by your left hemisphere. Therefore, at least temporarily, individuals or members of a team are more likely to think in a whole-brain manner. If the Medici Effect is used to assemble a team, the results will be even better. This method can also offer a means of addressing the brain's negativity bias—that is, the form of negativity bias that is fearful of trying something new and risky. You might offer a thought like this to a person who is reluctant to participate in What If because he or she sees no good coming out of such a ridiculous idea: "Yes, I know that What If sounds silly and risky, but let's proceed just for the fun of it." Finally, the often unusual ideas generated by What If stimulate the subconscious mind to ponder the implications.

4.12.8 Positive and Negative Features

The most positive aspect of What If is the likelihood of engaging both the left and right hemispheres of participants in an unrestrained manner and thus generating creative and innovative ideas. The principal negative aspect of What If is that it often suggests bizarre approaches that stand in strong conflict with left-brain thinking characteristic of the majority of engineers.

4.13 CONCLUDING THOUGHTS ABOUT BASIC WHOLE-BRAIN METHODS

Building on the case for more creativity and innovation presented in Chapter 1 and the brain primer offered in Chapter 2, this chapter offered you eleven easy to learn and use whole-brain methods. They will be followed in Chapter 7 by discussion of nine more advanced methods. However, that chapter aside, you now have the means in your individual and team efforts, within and outside of your studies and eventually in professional practice and beyond, to use one or more of eleven whole-brain methods. You are equipped to more effectively draw on that amazing entity between your ears.

> Today is a new day that has been handed to you for shaping.
> You have the tools; now get out there and create a masterpiece.
> —*Steve Maraboli, speaker and writer*

CITED SOURCES

Adams, R. 2014. "Bar Code 1." About.com. Accessed May 15, 2014. http://www.adams1.com/history.html.

Alessandra, T. 2015. "Using Behavioral Differences to Build Teams That Work." Accessed July 29, 2015. http://www.success.com/article/using-behavioral-differences-to-build-teams-that-work.

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. "Attitudes." In *Civil Engineering Body of Knowledge*, 2nd ed., 172–176. Reston, VA: ASCE.

Arciszewski, T. 2009. *Successful Education: How to Educate Creative Engineers*. Fairfax, VA: Successful Education LLC.

Baldwin, N. 2013. "Can You Hear Me Now?" *The Smithsonian*, December.

Bennett, J. 2010. "A Brief History of Micropiles." Accessed July 29, 2015. https://micropileman.wordpress.com/?s=a+brief+history+of+micropiles.

Bennett, J. K., and N. L. Hothem. 2010. "Hollow Bar Micropiles for Settlement Control in Soft Soils." Paper presented at the International Workshop on Micropiles, Washington, DC, September 22–25.

Berra, Y. 1998. *The Yogi Book*. New York: Workman Publishing.

Billington, D. P. 1996. *The Innovators: The Engineering Pioneers Who Made America Modern*. New York: John Wiley & Sons.

Boehler, P. 2012. "N. Joseph Woodland, Co-Inventor of the Barcode, Dies." *Time*, December 14.

Boorstin, D. J. 1985. *The Discoverers*. New York: Vintage Books.

Brenner, R. 2007. "Dismissive Gestures: Part I." *Point Lookout* e-newsletter, vol. 7, no. 12, March 21.

Brenner, R. 2008. "How to Eliminate Meetings." *Point Lookout* e-newsletter, October 1.

Brinkley, D. 2003. *Wheels for the World: Henry Ford, His Company, and a Century of Progress* 1903–2003. New York: Viking.

Brown, J. 2014. "Between Two Oceans: The Panama Canal." *Civil Engineering*, ASCE, July/August: 42–45

Buzan, T. 1984. *Make the Most of Your Mind*. New York: Simon and Schuster.

Buzan, T. 1983. *Use Both Sides of Your Brain*, rev. ed. New York: E. P. Dutton.
Buzan, T. 1991. *Use Both Sides of Your Brain*, 3rd ed. London: Penguin Books.
Byrne, J. 2005. "Brainstorming Helps Engineers Generate New Ideas." *Engineering Times*, December: 6.
Cain, S. 2012. *Quiet: The Power of Introverts in a World That Can't Stop Talking*. New York: Crown Publishers.
Carlson Learning Company. 1994. *Personal Profile System: A Plan to Understand Yourself and Others*. Minneapolis, MN: Carlson Learning Company.
Carter, R. 2009. *The Human Brain Book: An Illustrated Guide to Its Structure, Function, and Disorders*. New York: DK Publishing.
Civil Rights Digital Library. 2014. "Watts Riots." Accessed November 14, 2014. http://crdl.usg.edu/events/watts_riots/?Welcome.
Cooper, R. K. 2006. *Get Out of Your Own Way: The 5 Keys to Surpassing Everyone's Expectations*. New York: Crown Business.
Cross, H. 1952. *Engineers and Ivory Towers*. Edited by R. C. Goodpasture. New York: McGraw-Hill.
Culp, G. and A. Smith. 2001. "Understanding Psychological Type to Improve Project Team Performance." *Journal of Management in Engineering*, ASCE, January: 24–33.
Dhillon, B. S. 2006. *Creativity for Engineers*. Hackensack, NJ: World Scientific.
Fluoride Commission. 2014. *Report from the Fluoride Commission to the Valparaiso City Utilities Board of Directors*. Valparaiso, IN, August 21.
Fogler, H. S., S. E. LeBlanc, and B. Rizzo. 2014. *Strategies for Creative Problem Solving*, 3rd ed. Upper Saddle River, NJ: Prentice-Hall.
Fox, J. 2000. *How to Become a Rainmaker: The People Who Get and Keep Customers*. New York: Hyperion.
Fox, M. 2012. "N. Joseph Woodland, Inventor of the Bar Code, Dies at 91." *The New York Times*, December 12.
Fredrich, A. J., ed. 1989. *Sons of Martha: Civil Engineering Readings in Modern Literature*. New York: American Society of Civil Engineers.
Fruechte, R. 2014. Former director, Electrical and Control Systems Lab, General Motors R&D Center. Pers. comm., August 18 and September 16.
Gelb, M. J. 2004. *How to Think like Leonardo da Vinci: Seven Steps to Genius Every Day*. New York: Delta Trade Paperback.
Goldberg, D. E., and M. Somerville. 2014. *The Whole New Engineer: The Coming Revolution in Engineering Education*. Douglas, MI: ThreeJoy Associates.
Gross, R. 1991. *Peak Learning*. Los Angeles: Jeremy P. Tarcher.
Hensey, M. 1993. "Essential Tools for Total Quality Management." *Journal of Management in Engineering*, ASCE, October: 329–339.
Herrmann, N. 1996. *The Whole Brain Business Book: Unlocking the Power of Whole Brain Thinking in Individuals and Organizations*. New York: McGraw-Hill.
Johansson, F. 2006. *The Medici Effect*. Cambridge, MA: Harvard Business School Press.
Johnson, H. 2010. "Biz Tip of the Day." Email from training@globalteleclass.com, April 12.
King, B. R. 2007. "Virtual Teams Should Have Real Meetings." *COMMUNITYPOST*, e-newsletter, PMI, October 26.
Koberg, D., and J. Bagnall. 1991. *The Universal Traveler: A Soft-Systems Guide to Creativity, Problem-Solving, and the Process of Reaching Goal*. Menlo Park, CA: Crisp Publications.
Kolter, P., and K. F. A. Fox. 1985. *Strategic Marketing for Educational Institutions*. Englewood Cliffs, NJ: Prentice-Hall.

Leeds, D. 2000. *The 7 Powers of Questions: Secrets to Successful Communication in Life and Work*. New York: Berkley Publishing.

Lehrer, J. 2012. *Imagine: How Creativity Works*. New York: Houghton Mifflin Harcourt.

Leonard, D., and S. Straus. 1997. "Putting Your Company's Whole Brain to Work." *Harvard Business Review*, July–August: 1–10.

Liker, J. K. 2004. *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. New York: McGraw-Hill.

Lillibridge, E. M. 1998. *The People Map: Understanding Your People and Others*. Lutz, FL: Lilmat Press.

Macintyre, B. 2012. *Double Cross: The True Story of the D-Day Spies*. New York: Crown Publishers.

May, R. 1976. *Courage to Create*. New York: Bantam Books.

McCullough, D. 1977. *The Path between the Seas: The Creation of the Panama Canal 1870–1914*. New York: Simon & Schuster.

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

Milosevic, I. N. 2010. "Practical Application of SWOT Analysis in the Management of a Construction Project." *Leadership and Management in Engineering*, ASCE, April: 78–86.

Murray, D. K. 2009. *Borrowing Brilliance: The Six Steps to Business Innovation by Building on the Ideas of Others*. New York: Gotham Books.

Neumeier, M. 2014. "Dreaming: A Metaskill for the Future." *Rotman Management Magazine*, Spring: 24.

Nierenberg, G. I. 1982. *The Art of Creative Thinking*. New York: Barnes & Noble Books.

Oakley, B. 2014. "Learning Paradoxes." *PE*, National Society of Professional Engineers, November.

Osborn, A. F. 1953. *Applied Imagination: Principles and Procedures of Creative Problem-Solving*. New York: Scribners.

Parkinson, J. R. 2009. "Nothing More than Feelings, But that's How to Keep A Client." Show and Tell column, *Herald-Tribune*, Sarasota, FL, March 7.

Pisasale, P. E. 2014. Operations integrated product team lead, Seapower Capability Center, Raytheon Integrated Defense Systems. Pers. comm., October 27.

Prestpin, P. 2011. "Message Marketing with Mind Maps: Interests, Behaviors, Beliefs." *Website Magazine.com*, June 24.

Restak, R. 2009. *Think Smart: A Neuroscientist's Prescription for Improving Your Brain's Performance*. New York: Riverhead Books.

Reynolds, G. 2008. *Presentation Zen: Simple Ideas on Presentation Design and Delivery*. Berkeley, CA: New Riders.

Rhein, B. 2009. "Selling through Curiosity: Why the Right Questions Matter." Barry Rhein and Associates, webinar, July 8.

Rico, G. 2000. *Writing the Natural Way: Using Right-Brain Techniques to Release Your Expressive Powers*. New York: Jeremy P. Tarcher/Putnam.

Roane, S. 1988. *How to Work a Room: A Guide to Successfully Managing the Mingling*. New York: Shapolsky Publishers.

Rogers, J. D. 2014. "Engineering the Panama Canal." *Civil Engineering*, ASCE, October: 72–95.

Sandstrom, G. E. 1970. *Man the Builder*. New York: McGraw-Hill.

Shipping Container Pros. 2014, "Shipping Container Tips." Accessed September 17. http://www.shippingcontainerpros.com/about-us.php.

Singularity HUB. 2011. "10,000 Shipping Containers Lost at Sea Each Year." *Singularity HUB*, April 5. Accessed September 17, 2014. http://singularityhub.com.

Smallowitz, H., and D. Molyneux. 1987. "Marketing Strategies for Engineers." *Civil Engineering*, ASCE, August: 70–72.

Smiles, S. 1997. *The Life of Thomas Telford: Civil Engineer. Project Gutenberg*. Accessed August 5, 2014. https://archive.org/stream/thelifeofthomast00939gut/tlfrd10.txt.

Taco Bell. n.d. "Compton Comeback." Private video.

Tice, L. 2011. "Magic Words." *Winner's Circle Network with Lou Tice*, e-newsletter, July 18.

Tompkins, J. 1998. *Revolution: Take Charge Strategies for Business Success*. Raleigh, NC: Tompkins Press.

Van Doren, C. 1991. *A History of Knowledge*, Ballantine Book, New York, NY.

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. 1982. "Emergency Floodproofing of the Tecumseh Diecast Plant." Paper presented at the Seminar on Residential and Commercial Floodproofing, University of Minnesota, St. Paul, MN, March 1–2.

Walesh, S. G. 1990. "Water Science and Technology: Global Origins." In *Urban Stormwater Quality Enhancement: Source Control, Retrofitting, and Combined Sewer Technology: Proceedings of an Engineering Conference, Davos, Switzerland*, 1–27. New York: American Society of Civil Engineers.

Walesh, S. G. 2000a. "Decision Economics." In *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields*, 2nd ed., 209–276. Reston, VA: ASCE Press.

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

Walesh, S. G. 2004. "Lesson 15: So, What Do You Know About Bluebirds?" In *Managing and Leading: 52 Lessons Learned for Engineers*, 75–78. Reston, VA: ASCE Press.

Walesh, S. G. 2011. "Project Management and Creativity/Innovation." Part of the graduate course Master of Leadership in Engineering, Civil Engineering School, Castilla LaMancha University, Ciudad Real, Spain, September 19–22.

Walesh, S. G. 2012a. "Building: Construction and Manufacturing." In *Engineering Your Future: The Professional Practice of Engineering*, 283–297. Hoboken, NJ/Reston, VA: Wiley/ASCE Press.

Walesh, S. G. 2012b. "Developing Relationships." In *Engineering Your Future: The Professional Practice of Engineering*, 123–166. Hoboken, NJ/Reston, VA: Wiley/ASCE Press.

Walesh, S. G. 2014. "Five Habits of Highly-Effective Marketers: Engage Your Subconscious Mind." Webinar presented by the American Society of Civil Engineers, September 3.

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.

Wankat, P. C., and F. S. Oreovicz. 1993. "Psychological Type and Learning." In *Teaching Engineering*, 244–267. New York: McGraw-Hill.

Wheeler, R. 2014. "The Online Profile of Russell A. Wheeler." Accessed July 17. http://russellawheeler.com/resources/learning_zone/alex_f_osborn/.

Wilson, R. 2011. "The Ohno Circle." *Indiana Professional Engineer*, January/February: 3.

Wolff, J. 2012. *Creativity Now*. Harlow, UK: Pearson.

Yesiller, N. 2015. Director, Global Waste Research Institute, California Polytechnic State University, San Luis Obispo, CA. Pers. comm., May 8.

EXERCISES

Notes:

1. The goal of the exercises is to provide students, usually and preferably working in diverse groups, the opportunity to use all of the chapter's tools. Therefore, most exercises suggest use of a specific whole-brain method described in this chapter
2. However, many circumstances and corresponding teaching-learning opportunities may arise. For example, a team could use a different tool or more than one tool, or the stated issue may be altered to meet specific concerns or needs. Rather than work with the largely hypothetical situation described in a particular exercise, a team may wish to take on an actual issue, problem, or opportunity facing the team or one or more of its members. These and similar variations are encouraged, subject to the concurrence or direction of the instructor.
3. Recall the facilitation discussion in Section 3.8. Each of the team exercises provides opportunities for individual students to apply pre-, during-, and post-facilitation advice. Even if the instructor does not require facilitation, you may want to practice it for two reasons. First, your group will get better results. Second, students who provide facilitation will gain valuable knowledge and skills.

4.1 PREPARING FOR MEETING WITH A CLIENT (ASK-ASK-ASK): You are an engineer working for an engineering consulting firm and just received an email from a client you have worked with before. The client invites you to meet to discuss a problem that must be resolved. You naturally welcome the invitation, contact the client, and set up a time for a face-to-face meeting at the client's office. Read the following list of problems and select one for purposes of this exercise.

- **a.** An attempt is being made to encourage the cultivation of ginger and turmeric in a floodplain region. Scale-appropriate machinery needs to be designed and developed.
- **b.** A region known for its annual floods has very fertile lands. The client wants to encourage organic farming in the community and design appropriate machinery.
- **c.** The client is looking for a women-centered farm machinery and process redesign. The challenge here is also how to attract women to be machine-drivers and make it socially acceptable.
- **d.** Homestead gardens provide year-round nutrition to the communities of their region. But due to young people migrating, elderly family members are unable to tend properly to their gardens. The client is looking for feasible and low-cost solutions for this problem.
- **e.** The client owns power tillers and rents them for agricultural activities which are seasonal in nature. Hence the client is interested in exploring avenues for expansion in tiller accessories to make year round earnings.
- **f.** The client wants a greenhouse with a low cost of setup and operation to create a cooler and less humid environment than the surroundings.

Draft a list of questions you might ask during the meeting, possibly drawing on principles and tips in Section 4.2. Clearly, you have very limited

information about the client, his or her organization, and the issue. However, you should be able to formulate some questions using this chapter's Ask-Ask-Ask ideas. You are most effective if you can go into a win-win, question-asking mode regardless of the situation.

4.2 CONCEPTUAL DESIGN OF A "GREEN" BRIDGE (BORROWING BRILLIANCE): Assume that your multidiscipline consulting team has been retained by a US west coast river city to prepare the conceptual design for a bridge to further connect one side of the community to the other. Figure 4.27 shows the essential details of the valley cross section where the bridge is to be constructed.

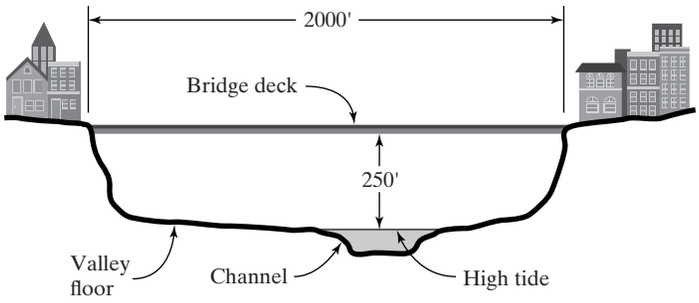


Figure 4.27
A bridge needs to be designed to cross this wide valley, provide for various forms of transportation, and generate energy.

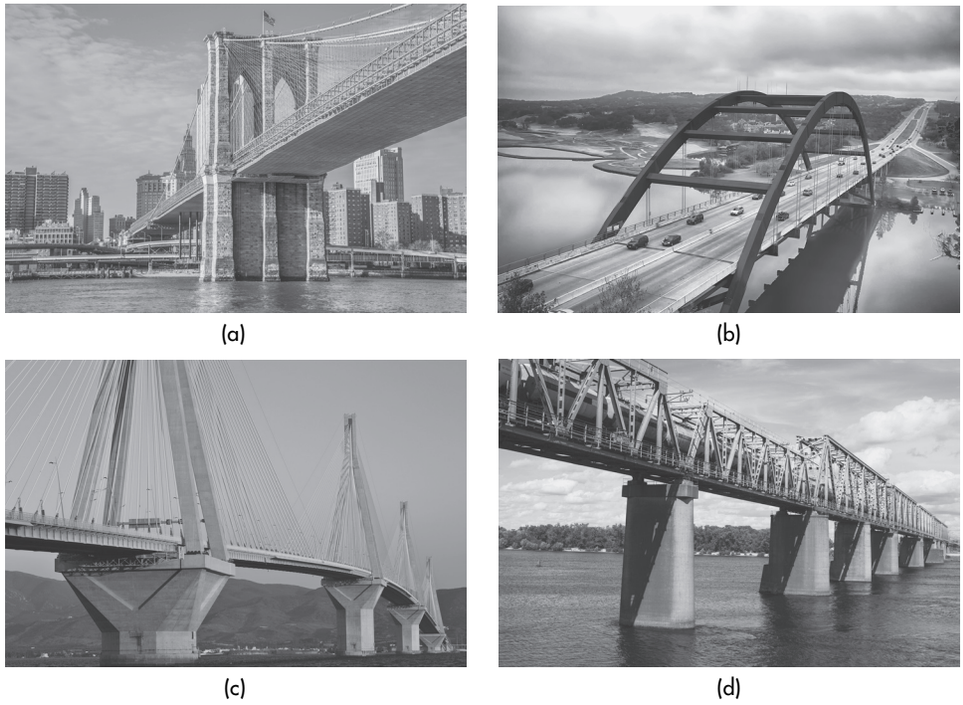
Note: Not to scale: great vertical exaggeration

Community leaders want the bridge to be functional; to generate energy and otherwise be "green"; and to make a statement—that is, become an iconic symbol for the city. Traditional functions to be provided include vehicle traffic, rapid transit, a pedestrian/biking path, and 250 feet of vertical clearance for ocean-going freighters and cruise ships. On the green front, the bridge is to have features such as turbines and/or solar panels, with one goal being to generate part of the community's energy.

The bridge deck shown in Figure 4.27 is meant to show the general location of traditional functions—that is, vehicle traffic, rapid transit, and a pedestrian/biking path. It is not meant to show the actual configuration of the structure that could be provided with various proven bridge structures shown in Figure 4.28, which include suspension, arch, and cable-stayed bridges, as well as piers and trusses.

Use Borrowing Brilliance to prepare a conceptual design. More specifically, for the borrowing part, think of various solar/turbine and other green applications you have seen, and research many more. Then, consider borrowing some of what you have experienced or learned for your conceptual bridge design. To reiterate, this is a conceptual design. Therefore, don't be concerned about cost, benefits, environmental impacts/approvals, and similar practical considerations at this stage. Focus on concepts. Think about what might be even remotely possible rather than what is likely to be practical.

Summarize your conceptual design with a three-part deliverable: a rough drawing that includes a cross section through the valley and shows the essentials of your conceptual design, descriptive text, and a list of all the sources you considered, even though some were not used. Demonstrate that you searched far and wide for concepts, ideas, technology, examples, and so on to borrow from.



(a) (b)

(c) (d)

Figure 4.28
Proven bridge structures include suspension, arch, and cable-stayed bridges, as well as piers and trusses.
((a) Rootstocks/Fotolia; (b) Elnur/Fotolia; (c) Gbbrowning/Fotolia; (d) Sonap/Fotolia)

4.3 ATTRACTING CITIZENS TO PUBLIC MEETINGS (BORROWING BRILLIANCE): Have you ever spoken to a community health worker (CHW)? They are the grassroots force delivering health services to the corners of any country. Since they interact very closely with the community, they are more aware of the needs, wants, ethos, culture, practices and beliefs of the community.

Now imagine that you are assigned a project to improve the health services in your locality. Depending on your specialization, you can try to focus on an engineering solution direction. For example, if you are a computer engineer, you can think of an IT-based solution; if you are a mechanical engineer, you might think of an automotive-oriented health service delivery mechanism, and so on. Engineering aside, first think of strategies and tactics that you can use to interact with all the involved stakeholders through public meetings.

These meetings can be organized in highly mixed groups, homogeneous groups or slightly mixed groups depending on the objective and stage of the project. Assume that you want to collect concerns, difficulties and opportunities in the process of healthcare delivery from all stakeholders. Using the approaches mentioned in Borrowing Brilliance, imagine creative ways of attracting a diverse group of stakeholders and citizens to your public meeting. How could you fill the room with a highly varied and representative audience? More specifically, ask each person in your hopefully diverse group why they go to certain community, business, sporting, entertainment, educational, and other events. What tactics could you borrow to increase the number and variety of individuals who come to your public meetings? Don't be bound by how it has always been done. Summarize your ideas in writing.

4.4 MULTIPLE USES OF HIGHWAY MEDIAN BARRIERS (BRAINSTORMING): Concrete and steel barriers, as shown in Figure 4.29, are routinely

used to separate opposing lanes of high-speed highways. They serve the single purpose of greatly reducing the likelihood of head-on collisions.

Imagine that your team is in the very early stages of planning and designing a high-speed highway system for a developing country. Median barriers are necessary. However, perhaps the barriers or a barrier system, could provide the opportunity to cost-effectively serve multiple purposes. Maybe the barrier system could fulfill many infrastructure and other functions. Use Brainstorming to identify possible uses of the barriers. Concentrate on developing many ideas; go for quantity, not quality. Summarize your results in a list of the ideas you generated.

Figure 4.29
Barriers are used between opposing lanes of high-speed highways to greatly reduce the likelihood of head-on collisions.
(Kenneth Sponsler/Fotolia; Unclesam/Fotolia)

4.5 POSSIBLE CAUSES OF BRIDGE FAILURE (FISHBONE DIAGRAMMING): A major bridge just failed, as shown in Figure 4.30, with loss of life and great disruption of river navigation and motor vehicle traffic. As an alternative, imagine the catastrophic failure of some other major structure, facility, system, or process; briefly describe or illustrate it; and proceed with the exercise.

Figure 4.30
This bridge failed with catastrophic results, and your team just arrived to begin assessing possible causes.
(Lunamarina/Fotolia)

Your engineering firm has been retained to analyze the failure and determine its cause or causes. Your interdisciplinary team (e.g., engineers, environmentalists, surveyors, divers) just made an initial one-hour visit to the site to view the failure. Before proceeding with determination of possible causes, your team decides to meet to plan its approach.

At the meeting, the group constructs a fishbone diagram. In applying Fishbone Diagramming, you try to imagine all the possible causes of failure. After completing the diagram, you intend to use it to develop your project plan—that is, who will do what, and when and how. However, for the time being, you are concentrating on the diagram. Summarize your results in the form of one fishbone diagram.

4.6 ASSESSING UNEXPECTED PRODUCT FAILURE RISKS (FISHBONE DIAGRAMMING): Assume that you are a manufacturer of fuel dispensers for gas stations. These dispensers are supposed to be shipped to different parts of the country with diverse climates and environmental conditions, and stand in the open without protection. For example, the north sees –20°C in winter while the east has very high humidity and flooding. The product has to be tamper-proof. Multiple safety features needs to be incorporated as it handles a highly hazardous product.

- Now your team sees an opportunity in the export market. For this, additional safety standards and regulations need to be considered and certifications obtained. In the international market, legislative measures are stronger and any product failure will mean a long-term legal battle for the company. Also usage and environmental conditions and related product abuse will be different.
- Yours is a small company and does not have the capacity to produce a completely new line of products for the international market. Thus the management decides to have a modular design with the possibility to customize it for the national or international market.
- Thus you invite a diverse group from engineering, marketing, servicing and so on for a meeting. You explain that you need their help in determining what could go wrong if we go ahead with the modular design idea for the national and international market.
- Then, you ask them to use Fishbone Diagramming to define what could go wrong—that is, what would need immediate attention. The head of your fishbone diagram might read "What could go wrong." As all of you work together on this exercise, think about material, weather, corrosion, safety, etc. Summarize your ideas with a fishbone diagram draft.

Note: The purpose is not to determine preventive actions (that would be the next step, and you are not being asked to do that) but rather to define the potential problem areas and problems. Recall that a problem well-defined is half-solved.

4.7 TEAM FORMATION (MEDICI EFFECT): Consider the problems mentioned in exercise 4.6. Each of these problems require the formation of a team consisting of experts from diverse disciplines, specialties and positions along with the affected stakeholders who might represent diverse geographies, ethnicities, genders, motivations, ages, experiences and attitudes. Assume that you have been asked to assemble the design team.

Assemble a hypothetical team using the Medici Effect as your guide. As you consider possible members, strive for the types of diversity outlined in Section 4.6 (Medici Effect) of this chapter. Avoid the cloning sameness approach to team formation. Do you think a Novice Effect can be utilized in the problem selected by you? Explain where and how it might be useful in your context.

Now when a team composition plan is ready, plan what steps you will take for team development as mentioned in Section 4.6.5.

4.8 YOUR PERSONALITY PROFILE (RELATED TO THE MEDICI EFFECT): This chapter's Medici Effect discussion mentioned personality (Section 4.6.2), which is in your bundle of habitual responses, and then went on to introduce personality profiles. If you have never had your profile analyzed, you may be interested in doing so, and this exercise provides the opportunity. If you have already been profiled, doing it again would be useful if for no other reason than to see if it changes (my experience and understanding is that it doesn't and therefore we have to work with what we and others have).

Personality profiles—ours and others—help us understand and deal with our feelings and needs and those of the people we work with and serve. The results of this exercise should be confidential, unless you want to share them with your instructor or other trusted persons.

a. Arrange for a personality profile assessment, possibly using one of the personality profiling systems noted in Section 4.6.3. As a student, you might get help from your campus career office or the health center. If you are an employee, seek help from human resources personnel.

b. Study the results, recognizing that there are no right or wrong profiles. They are what they are. Analyze your profile relative to your desired success and significance, as discussed in Section 1.2. What are your strengths and weaknesses or assets and liabilities, and what might you do about it? Also recall and learn from recent positive and negative interactions with students, faculty, coworkers, supervisors, and others in light of the added personal insight. Try to see how you and they might connect or disconnect based on your own profile and what you may be able to deduce about theirs. Going forward, maybe you can be more empathetic and develop or strengthen some of your relationships (Walesh 2012b).

4.9 MULTIPLE USES OF HIGHWAY MEDIAN BARRIERS (MIND MAPPING): See the situation described in Exercise 4.4. Then, apply Mind Mapping instead of Brainstorming. Summarize your results with your actual mind map and a list of ideas generated.

4.10 APPLICATIONS OF SHIPPING CONTAINERS IN DEVELOPING COUNTRIES (MIND MAPPING): A shipping container is "a standardized reusable steel box used for the safe, efficient, and secure storage and movement of materials and products within a global containerized intermodal freight transport system." *Intermodal* means that "the container can be moved from one mode of transport to another (from ship to rail to truck and in reverse) without unloading and reloading the contents of the container." Shipping containers, as shown in Figure 4.31, are seen on land and at sea all around the globe. At any time, about five to six million containers are being transported by ship, and about ten thousand are lost at sea each year as a result of falling off of ships (Singularity HUB 2011).

Figure 4.31
A shipping container is a standardized reusable steel box used for global intermodal shipping.
(Stuart Walesh)

Most shipping containers are eight-feet wide, nine-feet high, and twenty- or forty-feet long. They are constructed of corrugated steel and have large doors at one end. Used twenty-foot containers cost in the $1800 to $4500 range and forty-foot containers in the $2500 to $5500 range, and the cost may include delivery (Shipping Container Pros 2014).

Use Mind Mapping to generate a list of possible uses of shipping containers in poor, developing countries. The uses may be temporary or permanent and may involve one or many containers. Clearly, the containers could be used to provide homes—to provide shelter. However, go beyond that. Concentrate on developing many ideas, and don't evaluate them as they appear. Go for quantity, not quality. In the typical Mind Mapping application, practical considerations are deferred until later. Trying to combine idea generation with idea evaluation leads to neither being done well. Present your results by providing the actual mind map and a separate list of the ideas you generated.

4.11 APPLICATIONS OF SHIPPING CONTAINERS IN PUBLIC WORKS (MIND MAPPING): Review the shipping container information described in Exercise 4.10. Use Mind Mapping to generate a list of possible uses of shipping containers in public works. The use may be temporary or permanent and may involve one or many containers. What might you and your team do or want to do that might be accomplished with one or more shipping containers? Concentrate on developing many ideas, and don't evaluate them as they appear. Go for quantity, not quality. In the typical Mind Mapping application, practical considerations are deferred to later. Trying to combine idea generation with idea evaluation leads to neither being done well. Present your results by providing the actual mind map and a separate list of the ideas you generated.

4.12 EMERGENCY FLOODPROOFING OF A MANUFACTURING FACILITY (MIND MAPPING OR FISHBONE DIAGRAMMING): A manufacturing facility sits on the floodplain of a river, as shown in Figure 4.32, in a location that experiences severe winters. This 100,000 square foot (9,300 square meter) single-story concrete block building is constructed on a reinforced concrete slab. The principal product of the plant is aluminum castings.

These castings are shipped to two other plants, where they are used to manufacture small gasoline engines. Many containers of molten aluminum, kept molten by electric furnaces, are scattered throughout the plant. This manufacturing facility affects thousands of employees among the three plants and is critical to the local economy.

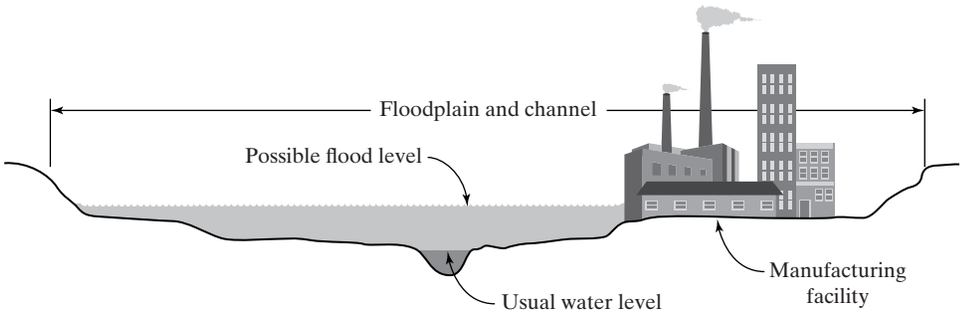


Figure 4.32
A manufacturing plant sits on the floodplain of a river.

As of February 1, as shown in Figure 4.33, the large watershed tributary to the plant's location contains heavy snow cover, and warmer weather is approaching. Flooding threatened the large single-story building in the past, and in the most serious event flood waters rose within inches of the concrete floor. Given the past history and this year's unusually heavy watershed snow cover, company management wants to take preventive action quickly. They want to keep the manufacturing going as long as possible, balanced by their concern about their employees and the facility.

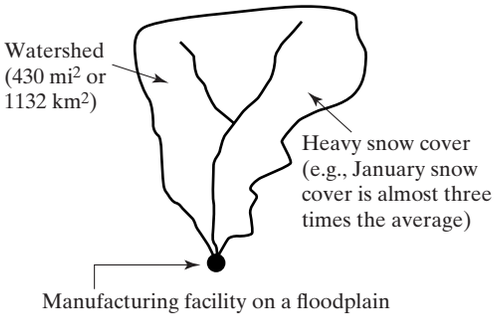


Figure 4.33
A manufacturing facility that is critical to the local economy sits on a floodplain and is threatened by flooding because of unusually heavy snow cover on the tributary watershed.

Your engineering firm has been retained as of February 1 to prepare an emergency floodproofing plan to protect the building, its equipment, and employees. Your plan must be ready in two weeks for review by company management, with the idea that if it is accepted it will be immediately implemented. *Note:* This exercise is based on an actual emergency situation and the response to it (Walesh 1982).

Definition of floodproofing: "Floodproofing consists of structural adjustments and other measures undertaken to reduce flood damage to an

existing or new residential, commercial, or industrial building, or other facility. Temporary floodproofing measures are those that are implemented for a short period of time, and usually on short notice, to provide protection during floods expected during a particular season or period. Subsequent to that flood threat, some of the temporary measures are typically removed or discontinued. The plan for temporary floodproofing measures, however, may be revised and used again during future flood events" (Walesh 1982).

Additional thoughts about floodproofing: "Regardless of the overall approach taken, the most cost-effective [emergency] floodproofing plan will probably include structural and nonstructural measures. That is, the plan should consider recommendations for temporary structural adjustments to be made to the building as well as recommendations for steps to be taken and procedures to be instituted to supplement structural adjustments" (Walesh 1982).

Use Mind Mapping or Fishbone Diagramming to develop a list of possible structural and nonstructural emergency floodproofing measures. Summarize your results by providing the actual mind map or fishbone diagram, and describe your ideas with text and, as needed, sketches or photos.

4.13 IMPROVING A TRADITIONAL PROCESS (OHNO CIRCLE): As individuals or groups, we often continue to carry out processes the way we have always done them. As students or in professional work, the process may be the way we study for examinations, design bridges, conduct meetings, use various materials, carry out laboratory experiments, set up manufacturing processes, or construct office buildings. Other individuals and teams do the same within their worlds of study, work, and beyond. Our and their approaches are comfortable and habitual. Therefore, although minor to major improvements may be possible, even the minor ones are not readily seen. The Ohno Circle, because of its emphasis on really seeing and hearing, can open our eyes and ears.

Select some process that you, as an individual, are interested in and can observe. It could be just about anything. Some examples: a local construction project, a meeting of your campus club, a bus stop with people getting on and off the bus, the first day of classes, or an intersection with pedestrian and auto traffic. The process does not have to have anything to with engineering.

Apply the thirty-minute version of the Ohno Circle method described in Section 4.8.1. Look for minor or major improvement opportunities in the categories defined in the text.

Search for ways to remove the deficiencies and make minor to major improvements, and make some of your suggested changes creative and/or innovative. Prepare a short report that includes the following sections:

- Description of the process you observed, preferably supplemented with photos/sketches.
- Assumptions: You may have been given or been able to obtain minimal information about the process you observed, and therefore you may need to make some assumptions.

- Sources used: If you used one or more outside sources, such as a website, reference book, published article or paper, or an expert, then list your sources.
- Description of suggested improvements categorized as minor and major.

4.14 IMPROVING A CONSTRUCTION OR MANUFACTURING PROCESS (OHNO CIRCLE): This exercise enables you to apply the Ohno Circle and critique a construction or manufacturing process (Walesh 2012).

a. Arrange to observe a manufacturing process that will be operating when you arrive or an active construction site where construction will be occurring while you are there. Inquire about safety measures, and then locate a place from which you can observe and hear all or most aspects of the construction or manufacturing for an extended period.

b. If you selected a manufacturing process, pretend you are its newly appointed manager. If you chose a construction site, imagine that you are the newly appointed construction project manager—that is, on the staff of the general contractor. Either way, you want to improve effectiveness and efficiency; do the right things and do them right.

c. Apply the Ohno Circle method, modified so that you stay at your observation point for perhaps only one hour, rather than the up to eight hours that Ohno required! The objective is to be there long enough to see and hear everything. Look for underutilized resources (e.g., personnel, equipment, materials); excess motion of personnel, unnecessary movement of parts or materials, excessive parts or materials; defects (e.g., production or constructed elements that do not seem to meet requirements); waiting due to materials, information, or resources that are not available where and when needed; and safety and health hazards.

d. Recognize that you are not qualified to do what you are doing, unless you have constructing or manufacturing experience. However, recall the novice effect (Section 4.6.3), because it may serve you well during this exercise. Hall of Fame baseball player Berra (1998) offers this sound advice: "You can observe a lot by watching."

e. Prepare a memorandum that addresses all of the preceding tasks, with emphasis on problems you observed and your ideas for resolving them.

4.15 GENERATING IDEAS (STREAM OF CONSCIOUSNESS WRITING): For this exercise, first use the individual and then the group mode.

In the individual mode, select an IPO. These can be any challenge, like selecting an elective, a career, or an internship; or an issue close to your heart; or a social or political cause. Write or type for ten minutes, recording whatever enters your mind. Don't let your pen or pencil leave the paper or your fingers leave the keyboard. Try not to repeat your thoughts.

You can write about the current problems, your ideas which resolve a part of the problem, a simplistic wishful thinking, or other solutions. You are very likely to gain new and useful insights into the issue. Given the possibly personal nature of the IPO selected, you may choose not to share your results.

In the group mode, form a team and choose an IPO relevant or important to the team. These can be problems related to your projects, a business idea you might have, common problems faced by the class or students group, or current social and political issues and so on. Repeat the 10 minute nonstop writing or typing exercise now followed by exchanging results with others in the group and continuing to write. A team may choose the option of confidentiality in disclosing insights in this case too. Compare the insights obtained in individual and group modes.

4.16 ANALYZE YOUR TEAM OR GROUP (SWOT): Imagine that you have to form a team for solving one of these tasks:

- A techno-cultural exhibition in the city.
- A greenhouse for growing tomatoes, which require a cold climate with low humidity, in a place which is hot and humid.
- An on-demand, multi-lingual and remote speech therapy service for people facing speech disorders.
- A piggery which is efficient but does not cause stress to build up in the pigs.
- A software for helping students conduct physics and chemistry experiments remotely.

Select a team or group to analyze and invite a variety of members, Medici Effect style, to join you in an objective analysis using SWOT. Begin by identifying those elements or aspects of your team or group that influence its performance. Some examples might be disciplines or specialties, writing and speaking knowledge and skill, IT capabilities, equipment, education and training programs, budget, mix of full- and part-time personnel, and other experiences. These elements become the rows in your SWOT table, as illustrated in Figure 4.14.

Lead the participants in determining the strengths, weaknesses, opportunities, and threats associated with each element and or aspect; fill in the rows. This process can be difficult, because some of the weaknesses or threats may be explicitly or implicitly directed at one or more participants. Nevertheless, a complete SWOT analysis can be helpful to both individuals and the team or group, assuming everyone is committed to improvement. While performing the analysis phase, do not discuss possible fixes. Separate problem definition from problem solution.

Once the analysis phase is complete, lead the group in prioritizing strengths and opportunities to be celebrated and enhanced and weaknesses and threats to be addressed. Then, generate ideas for building on strengths and weaknesses and for resolving weaknesses and threats. This is the point at which you might use idea-generating tools such as Borrowing Brilliance, Brainstorming, and Mind Mapping. Choose the course of action and develop an action plan.

Prepare a report that names and provides an overview of the team or group; presents the SWOT table; identifies the highest priority strengths, weaknesses, opportunities, and threats; indicates the selected ways to build on strengths and weaknesses and resolve weaknesses and threats; and outlines the action plan.

4.17 DEVELOPMENT OF SOCIAL MEDIA POLICY (TAKING A BREAK): Social media are defined as Internet-based means of self-publishing—that is, ways an individual can unilaterally place almost anything in cyberspace with the likelihood that it will be out there and discoverable forever! Examples of social media include LinkedIn, Facebook, YouTube, Twitter, and blogs. The variety and use of social media have exploded in recent years.

Although social media have great collaboration potential, their use by personnel in engineering firms and engineering-oriented government entities can lead to at least the following two types of problems:

- Misuse of time; that is, instead of carrying out job responsibilities, personnel are wasting time using social media.
- Making confidential or sensitive information widely available.

Assume that you work for an engineering firm or a government entity (pick one of the two). Your diverse team (you are the leader) has been assembled and charged with drafting social media policies to be followed by all personnel. The organization's top executive wants a list of creative and innovative social media guidelines that will help personnel make more effective use of their time and social media and also protect confidential information. Your draft will be reviewed by your organization's top executive.

You gather the team, discuss the issue, review the charge, obtain concurrence on team protocol, and then suggest using Taking a Break. Your rationale for that tool is that everyone uses social media. Now, after initially discussing the issue, social media will be on the conscious and subconscious minds of team members as they go about their work and other activities and use social media and see others use it. The next meeting is scheduled, and at that meeting, participants use Brainstorming or Mind Mapping to share ideas. Some of your team's intermeeting communication is very likely to occur via social media.

Play out the preceding two-meeting scenario, with the meetings separated by at least one day. Prepare and submit a list of creative and innovative social media requirements.

4.18 MANAGEMENT OF DISASTER WASTE AND DEBRIS (WHAT IF): Think of the types and huge amounts of waste and debris, as suggested by Figure 4.34, resulting from natural and other disasters. What should be done with it? This is a major problem.

Listen to Yesiller (2015) of the Global Waste Research Institute at California Polytechnic State University: "This is a topic that I have worked on some in the past and there is not really much information on the topic. Significant amounts of debris and waste are generated, in particular, subsequent to major events. Innovative solutions are required for sustainable management of these materials."

Use the What If tool to generate an initial set of ideas. For example:

- What if all the waste and debris was magically sorted? Then we could . . .
- What if all the waste was organic? Then we could . . .

Don't get in the weeds. Just use What If to generate as many ideas as you can. At this stage, go for quantity, not quality, and don't be concerned about practicality. As noted early in this chapter, when seeking creative and innovative solutions to challenges, we want to separate divergent thinking from convergent thinking and engage thoroughly in the former before beginning the latter. Summarize your initial ideas in the form of a list of ideas.

Then, select a few of the initial ideas, including some that appear ludicrous, discuss them, and see what additional related and more practical options might occur to you. Document your initial set of ideas and the results of your subsequent analysis of them.

Figure 4.34
Waste and debris resulting from natural and other disasters presents a major challenge.

(Benjamin Simeneta/Fotolia; Dmitry Naumov/Fotolia; Amelie/Fotolia)

4.19 RENOVATION/REUSE OF A MAJOR STRUCTURE/FACILITY (WHAT IF): The physical life of an engineered structure or facility, or any of its major components, is defined as the time over which the structure, facility, or component could perform its intended functions, assuming reasonable but not extreme care. Economic life is the period of time during which incremental benefits of use are likely to exceed incremental costs. In other words, the economic life of a structure, facility, or component ends when the incremental benefits of use become less than the incremental costs.

Clearly, determinations of physical and economic life are judgments. Of importance here is the observation that the economic life of an engineered structure or facility is usually significantly less than its physical life. For example, tanks, pipes, and other components in a wastewater treatment plant may have physical lives of up to fifty years, but given the rate of change of treatment technology, significant improvements are likely to occur in far fewer than fifty years. Therefore, a structure or facility may be taken out of service when many of its components still have significant physical life. Those parts may have salvage value—that is, monetary value (Walesh 2000a). On the other hand, the entire structure or facility, or major parts of it, might be renovated for a completely new use for public or private benefit.

Select an actual or hypothetical publically or privately owned engineered structure or facility. Some examples follow, but don't necessarily limit your choice to them:

- Airport
- Bridge
- Dam remaining after permanently dewatering a reservoir
- Elevated water storage tank—concrete or metal
- Football stadium
- Manufacturing plant
- Marina
- Nuclear power plant
- Outdoor swimming pool and complex
- Ski jump
- Transmission towers for electric power lines
- Wastewater treatment plant
- Water treatment plant

Temporarily set aside the original use of the selected structure or facility. Take a What If point of view: Figuratively look at it from above, below, inside out, and so on. Imagine other uses. After developing a list of possible reuses, select one. Then, identify some of the technical, economic, environmental, legal, regulatory, and other factors that would have to be addressed to implement it.

Summarize your initial ideas in writing, supplemented with sketches as needed. Describe the potential new use, and list factors that would need to be considered to further explore project feasibility.