Changing Our World: True Stories of Women Engineers. The book offers profiles of outstanding women engineers—past and present—who have significantly contributed to a better world (Hatch 2006). By inspiring and retaining young women in this way and others, the engineering profession will secure the next generation of role models for girls seeking a challenging, rewarding career.

The Next Steps

Engineers must engage in some radical thinking about education and about their public image. They must focus on how engineers will be required to think and work in a world in which complexity and change are not occasional events and in which the workplace is continuously responding to new technologies and to the 24/7 schedule made possible by the Internet. Engineers must rethink how they educate prospective engineers, beginning at the kindergarten level and proceeding through the university level and beyond.

Women members of the Japan Society of Civil Engineers believe that the steps to be taken to increase the number of women entering the engineering profession include improving the work environment, altering the male consciousness to become more cognizant of professional equality, educating men on the importance of sharing in child-care responsibilities, promoting women engineering role models, countering existing stereotypes within society, creating awareness of and encouraging discussion of gender difference issues, and continuing to gather statistics on the number of women entering and remaining in the engineering profession (JSCE 2004).

The 21st-century engineer must resolve to encourage individuals from all diverse groups to enter into the complex and dynamic field of engineering lest the profession squander the opportunity to maximize the potential for an infusion of intellectual capital. As Joseph Bordogna said in a 2004 speech:

> It is *not* about the total number of scientists and engineers the nation may or may not need. It's easy to get distracted by debates about trends and statistics that attempt to make the case that the demand for science, engineering and technology workers is greater or less than the supply. Rather, what it *is* about is drawing into the engineering and science workforce a larger propor-

tion of women, underrepresented minorities and persons with disabilities, no matter the workforce size. *Whatever the numbers turn out to be, we need a robust and varied mix*, and that means broadening participation. (Bordogna 2004, 5)

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Leadership

Leadership is most simply defined as the capacity to lead. However, leadership is also the ability to influence others for the purpose of positive gain—with or without the designated authority to do so. The traits generally viewed as conducive to leadership include commitment, confidence, communication, curiosity, entrepreneurship, a strong work ethic, an insistence on excellence, honesty, integrity, sound judgment, persistence, a positive attitude, and sensitivity. Desirable behaviors of leaders that can be taught and learned include earning trust, communicating well, thinking rationally, being open and consistent, demonstrating a commitment to organizational values, and using discretion when handling sensitive information.

Edward J. Hoffman, the director of the National Aeronautics and Space Administration's Academy of Program/Project and Engineering Leadership, emphasizes four central components of leadership:

1. *The desire to win:* successful leaders will endow their missions with a passion, enthusiasm, and commitment to succeed that is contagious.

2. *A focus on results:* effective leaders make certain that their teams understand the requirements and objectives that lead to project success.
3. *The ability to adapt to change:* good leaders establish a climate in which team members can respond productively to uncertainty or a shift in objectives.
4. *The ability to create an environment of trust:* successful projects rely on collaboration, which requires all team members—including employees, vendors, consultants, and partners—to trust one another. (Hoffman 2005, 22)

Leadership also entails transcending the ordinary to become someone whom others aspire to emulate. Leadership is about capturing the imagination and enthusiasm of others and bringing out the best in them both individually and collectively. At one time, U.S. engineers held significant leadership positions and were highly respected by the general public. George Washington, Theodore Roosevelt, Herbert Hoover, and Jimmy Carter, for example, were engineers who became U.S. presidents. These engineers who went on to assume the highest elected office in the United States consistently demonstrated to the public their commitment to the betterment of society while never losing sight of what engineering contributed to their development as leaders. In one of his often-cited speeches, President Herbert Hoover described the responsibilities and rewards of the engineering profession thus:

> It is a great profession. There is a fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. This is the engineer's high privilege. The great liability of the engineer compared to other professions is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like doctors. He cannot argue them into thin air or blame the judge like lawyers. He cannot, like the architects, cover his failures with trees and vines. He cannot, like the politician, screen his shortcomings by blaming his opponents and hope that the people will forget. The engineer simply cannot deny that he did it. If his works do not work, he is dammed. (Hoover 1961, 131–134)

The public perception today, however, is that engineers are not capable of being leaders—that they simply do not possess the requisite skills. Unfortunately, that perception is accurate, primarily because many engineers do lack the "soft" skills required for effective leadership. While engineering practice today requires formal training and experience, it also requires engineers to acquire skills that will reestablish them as leaders in the public's eye. Today's engineers simply must understand that if they do not acquire the "soft" skills needed to assume leadership positions they will not succeed in the 21st-century global marketplace.

What is the profile of today's successful leaders? Such leaders assume command of a situation and develop a course of action that ensures measurable progress and ultimate success. They possess the skills to develop strategy, think laterally, and lead by example while empowering a team or teams with the responsibility to carry out and complete tasks satisfactorily and while motivating team members through personal enthusiasm and charisma. Good leaders also learn from their mistakes. The Order of the Engineer, discussed in chapter three, has its origins in a tragic engineering mistake. In 1907, the Quebec Bridge over the St. Lawrence River in Canada collapsed, killing 75 workers and injuring 11 others. The collapse was attributed to engineers' failure to perform additional calculations to confirm the structural integrity of the span. All engineers learned and continue to learn from that mistake.

In 1940, the original Tacoma Narrows Bridge—situated on the Tacoma Narrows in Puget Sound near Tacoma, Washington—collapsed as a result of wind-induced vibrations. This collapse brought engineers worldwide to the realization that aerodynamic phenomena in suspension bridges were not adequately understood by the engineering profession and had not been adequately addressed in the bridge's design. Those who investigated the collapse recommended the use of wind-tunnel tests to aid in the design of the second Tacoma Narrows Bridge, and these recommendations resulted in the testing of all existing and future suspension bridges in the United States.

An error of far greater magnitude led to the 1981 Kansas City Hyatt Regency walkway collapse. One of the distinguishing features of the Kansas City Hyatt Regency was a multistory atrium that was traversed by suspended concrete walkways at the second, third, and fourth levels—the fourth-level walkway situated directly above the second-level walkway. The engineer had accepted the contractor's

change on the shop drawing for the walkway structural support rods because the revision would reduce installation cost and construction time. Tragically, this revision, which doubled the load on the connection between the fourth-floor walkway support beams and the tie rods carrying the weight of the second-floor walkway, resulted in increased static loads on the connections one July evening, when approximately 2,000 people were gathered in the atrium—dozens of them on the walkways—to observe a dance contest. When the live load exceeded the capacity of the structural support rods, the connection failed, and both walkways collapsed onto the atrium floor, killing 114 people and injuring 200 more.

Engineers who overlook or sidestep the importance of shop drawing review in the field or who are not mindful that a change to a shop drawing during construction can result in a fatal error like the Hyatt Regency tragedy must assume responsibility for their flawed judgment. Engineering leaders recognize the critical importance of design accuracy and precision and understand that there is absolutely no excuse for taking shortcuts in engineering practice.

Leadership versus Management

Leaders do not "manage" people, they inspire and guide them. Leaders are visionaries and strategists. Leaders maintain an open mind and listen to others. Leaders develop their own individual approaches to motivating and persuading others. Although the work engineers perform is important, the manner in which engineering leaders conduct themselves significantly affects the way their efforts are understood and appreciated by others. Leaders do not assume and do not merely rely on information they are told. Instead, leaders gather as much information as possible, separate the facts from fiction, and recognize how to understand the details without micromanaging. Leaders decide what must be done as well as how it must be done, decide the path an organization should follow, and set goals for achieving an organization's objectives. Leaders then motivate the organization's managers to execute established goals and objectives. And they do so by determining the strengths and knowledge of individual team members and then maximizing these strengths and this knowledge. In *The Engineering Profession*, Dan Henry Pletta presents his formula for successful leadership:

1. Convey a sense of mission.
2. Keep superiors informed.
3. Prepare a worst-case scenario.
4. Keep things simple and take note of early warnings.
5. Seek help quickly when it is needed.
6. Take reasonable risks, and do not become obsessed with failure.
7. Cultivate a how-to-cope attitude.
8. Do not lose touch with coworkers, and listen to their opinions.
9. When criticism becomes necessary, administer it in small doses at first and do not humiliate individuals in front of others.
10. Motivate subordinates by assigning challenging opportunities and praising their achievements.
11. Be fair; strict, but fair.
12. Strive for excellence.
13. Make decisions and accept responsibility.
14. Issue directions that facilitate acceptance without resentment.
15. Recruit and train capable subordinates to prevent group failures. (Pletta 1984, 196–197)

The primary distinction between leadership and management is that leadership entails the development and execution of a vision whereas management entails the oversight of individuals and other resources to effect the execution of that vision. Managers may in due course become leaders, but that path is not assured; leadership requires considerable creativity while management does not. But leadership does require an understanding of some principles that are applicable to the oversight of individuals—principles used to lay the foundation of effective, productive organizations and teams, which play critical roles in the execution of a vision. These principles fall within four categories: effective communication, value principles, synergy principles, and investment principles (Cottrell 2002).

The components of *effective communication* for a leader are building trust; honoring commitments, or keeping promises; sharing knowledge; and providing feedback. A leader must gain trust from team members; failure to do so will compromise the work of the team, because if there is a lack of trust, whatever the leader communicates to team members will be viewed as suspect. A leader must also honor commitments—for example, must consistently meet deadlines—or

the team will lose confidence in the leader's ability. Leaders must also share their knowledge with team members so that team members learn from the leader and understand the leader's vision for any given undertaking. Feedback to team members is critical. Not only do individual team members learn whether or not they are meeting expectations, they also learn how their performance is or is not contributing to the overall team goals and objectives.

Value principles form the foundation of earning respect and are categorized as principles of integrity, principles of responsibility, principles of commitment, and principles of vision. Principles of integrity ensure that what is accomplished by the leader and by the team is accomplished honestly. Principles of responsibility ensure that the leader accepts the consequences when things go wrong and does not blame other team members. Principles of commitment guide the team in achieving excellence; the team leader makes a commitment to a job well done and, by example, inspires all of the team members to meet a standard of excellence. Principles of vision provide each and every team member with a clear view of the leader's vision so that each member can embrace this vision.

Synergy principles constitute the glue that holds the team together and include the principle of communication, the principle of conflict resolution, the principle of optimism, and the principle of change management. Effective communication is essential to team cohesion. When team members have a clear understanding of the leader's expectations—the result of effective communication on the part of the team leader—they are more likely to perform well. And when conflict arises between team members, a strong leader knows how to address it. Conflict is not necessarily problematic. Opposing points of view can result in the advancement of new ideas or new solutions to problems. It is important, however, for the leader to know when and how to negotiate with individuals who cannot resolve their conflict so that the team's goals and overall performance are not jeopardized. Optimism is infectious and goes a long way toward bolstering team confidence and morale and sustaining enthusiasm for the team's objectives. Strong change management skills are critical to effective leadership in the engineering profession because engineering projects seldom unfold precisely as planned.

Investment principles are the intangibles that enhance teamwork and include the principle of empowerment, the principle of courage, the principle of good example, and the principle of preparation.

Empowerment is simply providing a team member with an opportunity and the resources to use it. It conveys the sense that the leader has confidence in an individual's ability to achieve. For the purposes of this discussion, courage is defined as not fearing the difficult situations that arise during the course of every project and as standing up for one's beliefs. It also means not backing down during encounters with difficult individuals in powerful or leadership positions. The principle of good example means that it is the leader's role to lead by example. For instance, the leader does not leave until the day's work is complete. The leader shoulders as much work as the other team members and, more often than not, usually shoulders more work than the other team members. The result is that the team works more efficiently and more productively because the members are giving their all to the team effort. Preparation is synonymous with doing one's homework. The key to success is preparation and hard work, and the effective leader prepares thoroughly prior to meeting with a client, for example. Being well prepared very often determines whether one secures a contract with a client.

The Art of Mastering Leadership Skills

Almost all engineering education is technical; engineers are not taught how to lead, they are taught how to become engineers. Engineers must be taught to be leaders by supervisors who mentor them, or they must acquire leadership skills on their own initiative. While the engineering leader's skill set embraces a number of competencies, there are three basic keys to leadership success that can be easily applied to the engineering profession: communication, confidence, and commitment.

Communication

Communication is discussed extensively in chapter two relative to the basic communication skills necessary for engineers and earlier in this chapter relative to the supervision of individuals. The communication skills required by engineering leaders are discussed here in a more specific sense with regard to how an engineer communicates effectively with fellow engineers within a professional organization; with other employees within a professional organization; with students in the classroom; and with the public, lawmaking bodies, and clients.

Prior to delivering a speech or making a presentation, for example, the engineering leader must do his or her homework to gain an understanding of the audience's or client's background and specific needs. People have more respect for those who take the time to understand specific situations and specific needs. Speaking and writing should be undertaken with both appropriateness and sensitivity. Bringing clarity to complex material is a key component of the engineering leader's communication. While a more formal approach may be appropriate when one addresses lawmakers, the public, and/or the media, a more informal approach may be more appropriate when one speaks to employees, because such an approach serves to demonstrate collegiality.

Engineering leaders must also recognize the fact that engineering work is not performed in a vacuum, but rather is accomplished through the efforts of a team. Engineering leaders must understand that the team's accomplishments are dependent upon the leader's ability to motivate team members individually and collectively. Leaders must therefore share information so that each team member understands the goals and objectives of the team's undertakings. A leader should never assume that team members are fully aware of his or her expectations. Expectations must be clearly communicated to each team member. It is also important to bear in mind that accessibility, collegiality, civility, and empathy on the part of a leader go a long way toward establishing and maintaining good team/employee morale.

Good ideas are generated by individuals, but great ideas are accomplished through team discussion and deliberation. Communication plays a key role in how teams best accomplish their tasks. In today's global economy the engineering leader further recognizes that teams will be diverse and that the strength of the team is dependent upon this diversity. The good engineering leader also recognizes that in the end the credit for the outcome will be awarded to several minds, not just one. True leaders are not those who strive to be first but those who are first to strive and who give their all for the success of the team. True leaders are the first to determine a need, envision a plan to satisfy that need, and empower a team to carry out that plan. The power of the team is unleashed by the strength of the leader's commitment. As Alexander Graham Bell once noted, "Great discoveries and improvements invariably involve the cooperation of many minds. I may have been given credit for having blazed the trail, but when I