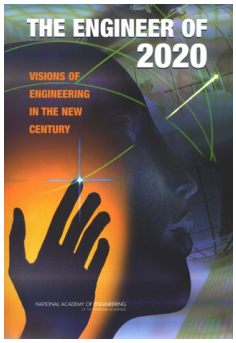
national reports

THE ENGINEER OF 2020

National Academy of Engineering Report

CONNECTIONS BETWEEN ENGINEERING PAST, PRESENT, AND FUTURE



Many of the key attributes of engineers in 2020 will be similar to those of today but made more complex by the impact of new technology. In reviewing these enduring attributes for engineers, we also identify the essential characteristics that connect engineering's past, present, and future. As with any profession, we also recognize the imperative to remain flexible and to embrace necessary changes that allow for constant success. These new-century reflections on engineers in 2020 are outlined below.

The word engineer has its roots in the Latin word *ingeniator*, which means ingenious, to devise in the sense of construct, or craftsmanship. Several other words are related to ingeniator, including *ingenuity*.

National Academy of Engineering. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: The National Academies Press, 2004. Pages 52-57.

https://www.nap.edu/catalog/10999/the-engineer-of-2020-visions-of-engineering-in-the-new

Engineers in 2020, like engineers of yesterday and today, will possess **strong analytical skills**. At its core, engineering employs principles of science, mathematics, and domains of discovery and design to a particular challenge and for a practical purpose. This will not change as we move forward. It has been stated in earlier sections that the core knowledge base on which engineers develop products and services may shift as technologies involving the life sciences, nanoscience, optical science, materials science, and complex systems become more prevalent. Also, information and communications technologies will be ubiquitous—embedded into virtually every structure and process and vital to the success and usefulness of all engineered products. Just as important will be the imperative to expand the engineering design space such that the impacts of social systems and their associated constraints are afforded as much attention as economic, legal, and political constraints (e.g., resource management, standards, accountability requirements). Engineers will also concentrate on systemic outcomes in the same ways that focused outcomes are considered. Even though the scientific knowledge that defines operating principles is expected to be more fluid and more complex, the core analysis activities of engineering design—establishing structure, planning, evaluating performance, and aligning outcomes to a desired objective—will continue.

Engineers in 2020 will exhibit **practical ingenuity**. The word engineering derives from *ingeniator* (Johnston et al., 2000). Yesterday, today, and forever, engineering will be synonymous with ingenuity—skill in planning, combining, and adapting. Using science and practical ingenuity, engineers identify problems and find solutions. This will continue to be a mainstay of engineering. But as technology continues to increase in complexity and the world becomes ever more dependent on technology, the magnitude, scope, and impact of the challenges society will face in the future are likely to change. For example, issues related to climate change, the environment, and the intersections between technology and social/public policies are becoming increasingly important. By 2020 the need for practical solutions will be at or near critical stage, and engineers, and their ingenuity, will become ever more important.

Creativity (invention, innovation, thinking outside the box, art) is an indispensable quality for engineering, and given the growing scope of the challenges ahead and the complexity and diversity of the technologies of the 21st century, creativity will grow in importance. The creativity requisite for engineering will change only in the sense that the problems to be solved may require synthesis of a broader range of interdisciplinary knowledge and a greater focus on systemic constructs and outcomes.

As always, good engineering will require good **communication**. Engineering has always engaged multiple stakeholders—government, private industry, and the public. In the new century the parties that engineering ties together will increasingly involve interdisciplinary teams, globally diverse team members, public officials, and a global customer base. We envision a world where communication is enabled by an ability to listen effectively as well as to communicate through oral, visual, and written mechanisms. Modern advances in technology will necessitate the effective use of virtual communication tools. The increasing imperative for accountability will necessitate an ability to communicate convincingly and to shape the opinions and attitudes of other engineers and the public.

In the past those engineers who mastered the principles of **business and management** were rewarded with leadership roles. This will be no different in the future. However, with the growing interdependence between technology and the economic and social foundations of modern society, there will be an increasing number of opportunities for engineers to exercise their potential as leaders, not only in business but also in the nonprofit and government sectors. Policy decisions in technological societies will demand the attention of leaders who understand the strengths and limitations of science and technology. New levels of sophistication will be needed as choices that affect physical, human, and political infrastructures and decisions that define priorities and objectives for a community, region, or nation are made.

In preparation for this opportunity, engineers must understand the principles of **leadership** and be able to practice them in growing proportions as their careers advance. They must also be willing to acknowledge the significance and importance of public service and its place in society, stretching their traditional comfort zone and accepting the challenge of bridging public policy and technology well beyond the roles accepted in the past.

Complementary to the necessity for strong leadership ability is the need to also possess a working framework upon which **high ethical standards** and a strong sense of **professionalism** can be developed. These are supported by boldness and courage. Many of the challenges of the new century are complex and interdependent and have significant implications for the technologies intended to address them and the ways in which those technologies affect the planet and the people that live here. Effective and wise management of technological resources is integral to engineering work. The choices will be gray in nature, balancing (for example) economic, social, environmental, and military factors. Leaders, and those who influence these choices, will benefit from a sense of purpose and clarity. Successful engineers in 2020 will, as they always have, recognize the broader contexts that are intertwined in technology and its application in society.

Given the uncertain and changing character of the world in which 2020 engineers will work, engineers will need something that cannot be described in a single word. It involves **dynamism**, **agility**, **resilience**, and **flexibility**. Not only will technology change quickly, the social-political-economic world in which engineers work will change continuously. In this context it will not be this or that particular knowledge that engineers will need but rather the ability to learn new things quickly and the ability to apply knowledge to new problems and new contexts.

Encompassed in this theme is the imperative for engineers to be **lifelong learners**. They will need this not only because technology will change quickly but also because the career trajectories of engineers will take on many more directions—directions that include different parts of the world and different types of challenges and that engage different types of people and objectives. Hence, to be individually/personally successful, the engineer of 2020 will learn continuously throughout his or her career, not just about engineering but also about history, politics, business, and so forth.

What attributes will the engineer of 2020 have? He or she will aspire to have the ingenuity of Lillian Gilbreth, the problem-solving capabilities of Gordon Moore, the scientific insight of Albert Einstein, the creativity of Pablo Picasso, the determination of the Wright brothers, the leadership abilities of Bill Gates, the conscience of Eleanor Roosevelt, the vision of Martin Luther King, and the curiosity and wonder of our grandchildren.

Lillian Gilbreth is known as the Mother of Ergonomics, a branch of engineering devoted to fitting the workplace to the worker. Ergonomics involves the application of knowledge about human capacities and limitations to the design of workplaces, jobs, tasks, tools, equipment, and the environment. Gilbreth's approach transformed the engineering activity by introducing a primary focus on human needs and capacities. She was recognized for her contributions by being the first woman elected to the National Academy of Engineering in 1966.
