



July 2018

Workshop HIGHLIGHTS

Adaptability of the US Engineering and Technical Workforce

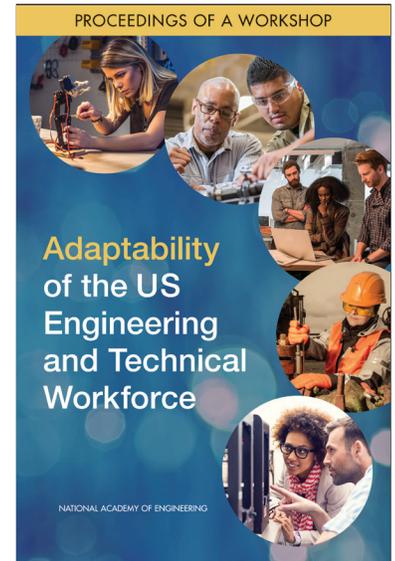
In 2015 the National Academy of Engineering (NAE) released the report *Making Value for America: Embracing the Future of Manufacturing, Technology, and Work*, which noted that technological developments, reengineered operations, and economic forces are transforming the way products and services are conceived, designed, made, distributed, and supported, a transformation that is having profound effects on the world of work. To explore the effects of these changes on the workforce and on individual workers, the NAE held a workshop November 2–3, 2017, entitled “Preparing the Engineering and Technical Workforce for Adaptability and Resilience to Change.” The first goal of the workshop was to increase stakeholders’ understanding of both the importance of workforce adaptability and the definition and characteristics of adaptability. The second goal was to provide an opportunity to share best practices for fostering adaptability and to identify needs for future study and development.

CONTEXT AND OVERVIEW

As Nick Donofrio, fellow emeritus at the IBM Corporation and chair of the committee that produced *Making Value for America*, observed, the continually changing demands of the workplace have created an imperative for workers to be adaptable. People need to be able to innovate and change in a collaborative, open, and inclusive way.

Information technologies and new business opportunities are fundamentally changing the marketplace, the world of work, and every aspect of business operations, noted Theresa Kotanchek, chief executive officer and cofounder of Evolved Analytics, who chaired the steering committee that organized the workshop. She quoted a statement attributed to Charles Darwin: “It’s not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.”

Kotanchek added that the workshop was designed to tap into the “power of we.” It was structured to bring together people from different sectors—



business, education, and government—to share best practices, learn from each other, identify unmet needs, and articulate how better to meet those needs.

Frans Johansson, an expert on innovation and the keynote speaker at the kickoff dinner, observed that the world is facing an onslaught of trends and developments that are making the future exceedingly uncertain. In the face of this uncertainty, organizations and individuals alike need a strategy for adaptation, and he articulated four elements of such a strategy: placing multiple bets; combining expertise and skills with new fields, industries, and cultures; preparing for unpredictability; and enhancing the speed of innovation. But organizations have different ways to adapt than do individuals. Individuals need to iterate themselves quickly. Companies need to place multiple bets simultaneously. The best preparation for adaptability, he said, is combining building blocks of knowledge.

WHY IS ADAPTABILITY IMPORTANT?

The first panel, moderated by Wanda Reder, chief strategy officer at S&C Electric Company, looked at the broad question of why adaptability is important. The panelists—an economist with a technology company, the leader of a utility company, and a university administrator¹—had very different backgrounds, but agreed that people working in the modern economy need to be adaptable to deal with an uncertain future.

Workers need both durability (the ability to survive change) and adaptability (the ability to shift to a new direction), said Guy Berger, chief economist with LinkedIn. Core cross-functional skills that are transferable across multiple industries and functions are critical in a rapidly changing economy. The payoff from adaptability can be large. According to a report prepared by PwC for LinkedIn, greater worker adaptability could create \$130 billion of additional productivity annually for the 11 countries examined in the report, including \$30 billion in the United States.²

However, he continued, market forces and the educational system are pushing people to acquire narrow skills rather than broad skills needed for adaptability. He also recognized that people need some level of economic security to be adaptable so that they feel they can take the chance to learn new skills to complement their existing ones.

Greg Dudkin, president of PPL Electric Utilities, made the case that individuals and organizations need adaptability, curiosity, humility, a capacity to innovate and learn continuously, and the ability to deliver results while monitoring trends in industry and technology. “If [adaptability] is really important for somebody even in the electric utility industry, then it’s got to be important for everybody,” he said. Long-term success requires establishing the right culture, and strong leadership and identification of a value proposition can create a culture of adaptability.

Dudkin said that his company is very transparent about what is happening both in the industry and in the company, in terms of both challenges and opportunities. Some people are not interested in changing, he acknowledged, but the company is committed to explaining how the future will be different and how employees can prepare for that future.

In the past, humans were conditioned to act more like machines, whereas in the future machines will increasingly have the capabilities to be more like humans, said Robert Johnson, chancellor of the University of Massachusetts, Dartmouth; at present, modern societies are at an inflection point between the past and the emerging future. Workers have shifted from generalists to specialists to hyperspecialists to neogeneralists. Colleges need to educate young people for jobs that do not yet exist using technologies that have not yet been created to solve problems that have not yet been identified.

People therefore need to learn to learn and learn to do throughout their lifetimes. “Value creation will come out of that as a natural process,” he said. “We want to give young people knowledge and the power of learning. . . . We want to give them uniquely human skills that robots cannot do. If they have that, they will be adaptable and will be able to create value in the marketplace.”

¹ Nick Donofrio was also a panelist. His remarks from this and other points in the workshop are noted earlier and consolidated in chapter 1 of the report.

² PwC. 2014. Adapt to Survive: How Better Alignment Between Talent and Opportunity Can Drive Economic Growth. Available at <https://www.pwc.com/gx/en/hr-management-services/publications/assets/linkedin.pdf>.

WHAT DOES ADAPTABILITY LOOK LIKE?

The second panel, moderated by Ann McKenna, professor of engineering and director of the Polytechnic School in the Arizona State University Ira A. Fulton Schools of Engineering, looked at the constituent skills and attributes of adaptability at four levels: individual, interpersonal, team, and organizational. The characteristics of adaptability at each level are somewhat different, the panelists observed, but there are commonalities across all four, such as the role of motivation.

Adaptability is a change in behavior as the environment changes that improves outcomes, said Christian Schunn, senior scientist at the Learning Research and Development Center and professor of psychology, learning sciences and policy, and intelligent systems at the University of Pittsburgh. People adapt whether or not they are aware of environmental changes. Adaptation can be slow and typically includes a time lag, but people who are aware of a changing environment tend to adapt more quickly, and those who adapt more quickly succeed more often in dynamic tasks.

Ernest Wilson, founding director of the Center for Third Space Thinking and professor at the Annenberg School for Communication at the University of Southern California, placed the idea of adaptability in a broader context of interpersonal and interactive skills, providing a “liaison” between individual and team adaptability. Cultural competency, intellectual curiosity, empathy, 360-degree thinking, and adaptability are skills that people need in order to be able to work readily with others.

Adaptation is often not easy, Wilson acknowledged; it can be affected by societal volatility, uncertainty, complexity, and ambiguity. Emphasizing the transitions under way in society can help convince people that adaptability will affect not only their company’s performance but also their individual performance. He noted that exercises in training and leadership development are greatly appreciated. “It turns out that fairly straightforward, simple, hands-on, teamwork activities...have a very positive impact at the macro level to explain the urgency and universality of the changes.”

Individuals are embedded in the context of social organizations’ hierarchical structure, said Steve Kozlowski, professor of organizational psychology at Michigan State University. That top-down context influences and constrains behavior at lower levels of the system, which can facilitate or inhibit adaptation. In this way, team adaptability both shapes and reflects adaptability at other levels, from the individual to the organizational. At the same time, team processes produce bottom-up phenomena shaped by the attributes of individuals and how they interact. The adaptive capabilities of teams are emergent and can be nurtured and shaped, and interventions can be effective, if underlying mechanisms of team formation and contextual factors are known.

Kozlowski explained that adaptability can be either domain general or domain specific. Domain general is about human capital—hiring people with certain capabilities; domain specific is about training—developing certain skills. From a training and development viewpoint, it is important to remember that team adaptability is emergent and evolves over time. Creating “desirable difficulties” for the learner can be a useful approach to training.

Like individuals and teams, organizations can learn, observed Linda Argote, David M. and Barbara A. Kirr Professor of Organizational Behavior and Theory in the Tepper School of Business at Carnegie Mellon University and director of the Center for Organizational Learning, Innovation and Knowledge. Organizations show considerable variation in the rate at which they learn—some exhibit dramatic improvement, while others show little or no learning. Even different parts of the same organization that have the same structure and make the same product may learn at different rates.

According to Argote, four factors—training, transactive memory, effective use of technology, and knowledge transfer—contribute to organizations’ rates of learning. Training affects individuals in different ways, but organizations can shape training so that it has an optimal effect on organizational learning. Transactive memory (knowledge of who knows what) allows members of a team to specialize and share capability, providing access to more information than an individual possesses. The introduction of technology can speed progression along the learning curve, especially when individuals and teams can embed expertise in a technology system, which then can spread the knowledge to other parts of an organization. This knowledge transfer process spreads lessons learned in one unit of an organization to others and improves the performance of the recipient units.

During the question-and-answer session the four panelists considered whether adaptability can be taught directly or whether training needs to put people in situations where they are forced to be adaptable in order to learn to be adaptable. They cited the need for both domain-general and domain-specific adaptability, the risk of “unlearning” skills, and learning by doing as important to training for adaptability. Another prominent topic of discussion was the continued need for hands-on work as the workplace becomes more automated.

HOW CAN ANALYTICS BE USED TO MAKE DECISIONS ABOUT ADAPTABILITY?

In the third panel, moderated by Annette Parker, president of South Central College, presenters described methods to analyze and shape adaptability and programs designed to foster adaptability. For example, labor market data can help organizations and individuals understand their environment to better facilitate adaptation, and measures of individual and organizational adaptability can guide decisions and future actions.

Sandee Joppa, executive director of RealTime Talent, explained how labor market data can inform stakeholders about the best ways to address workforce shortages and skill gaps. Her organization in Minnesota works with employers and employer associations in industries, large higher education institutions, and the state government to provide localized, up-to-date information on job openings and job seekers. A major benefit of the system is its analysis of the data. Information drawn from online job posting systems across all occupations can help identify the foundational “agility skills” that are in demand.

Change is frequent in organizations and increasingly requires employees to adapt to new situations, observed Tracy Kantrowitz, director of talent solutions at PDRI. But adaptability is a multidimensional concept that varies from one job to another. Thus, there is no single way to measure adaptability. Instead, it needs to be measured across the employee lifecycle, from the determination of adaptive performance requirements to selection of more adaptable employees to management of adaptive performance. Kantrowitz described the Job Adaptability Inventory as one method to determine the adaptive performance requirements of a job and identify which dimensions of adaptability are most relevant.

While adaptability differs from job to job, Kantrowitz pointed out that many jobs require a core set of adaptability skills: creative problem solving, working across teams, and comfort with multidisciplinary environments as employees learn new technologies and procedures. She also noted the importance of training adaptable leaders by exposing them to situations requiring adaptability so they have a catalogue of experiences on which to draw.

Susan Straus, senior behavioral scientist at RAND, described a RAND evaluation of a course that the US Army developed to train adaptive leaders using the Individual Adaptability Theory. The ten-day course involves little classroom time and a number of practical experiences, such as problem solving and teamwork. Assessment of the effectiveness of the training indicates that the program is successful but more in-depth evaluation is needed.

Both Straus and Kantrowitz noted that adaptability assessment tools exist but this work is still in its early stages. Best practices or best instruments have not yet been identified.

TRAINING AND ORGANIZATIONAL CHANGE

In two “lightning round” panels presenters briefly described activities related to adaptability in their organizations. Workshop participants then worked in teams to identify major points, common themes, and remaining questions that emerged from the presentations. The first lightning round, on the use of training and organizational change to enhance adaptability, was moderated by Mary Ann Pacelli, manager of workforce development at the Manufacturing Extension Partnership, National Institute of Standards and Technology, US Department of Commerce.

Jim Johnson, Jr., vice president of US production operations for S&C Electric Company, described the company’s approach to building an adaptable workforce using a career framework with well-defined work elements and the skills needed to be proficient in each. The framework guides the acquisition of multiple skills, simultaneously allowing employees to build a career path and making the company more nimble.

Blake Consdorf, president and CEO of Felsomat USA, explained how the company is partnering with a local community college to instill skills in real-world problem solving. The classes at the community college do not

take the form of a step-by-step learning process. Rather, an instructor may leave out some parts or present an incorrect drawing, challenging students to be adaptable in the face of real-world problems.

Steve Partridge, vice president of workforce development for Northern Virginia Community College, reported that companies are less likely to pay for their employees to develop adaptability skills such as communication, program solving, and critical thinking—skills companies have identified as the most important—than they are to pay for more narrowly focused skills, such as coding. Community colleges need to help change that dynamic.

The Kern Entrepreneurial Engineering Network (KEEN) is a partnership of higher education institutions helping each other adapt their undergraduate engineering programs by putting value first and tools second, said Douglas Melton, program director at the Kern Family Foundation, so that “know-why” is supported with “know-how.” Adaptability of the future technical workforce depends directly on the adaptability of its education. As part of this adaptability, college and university engineering programs should encourage all their students to develop an interest in both the economic and societal value they can create in their jobs.

Carra Sims, senior behavioral and social scientist with the RAND Corporation, elaborated on RAND’s evaluation of the US Army adaptation course described by Straus in the previous session. Evaluation of training and educational programs can identify facilitating factors and challenges in developing and applying adaptability skills.

After the presentations, workshop participants discussed takeaways and remaining questions. Among these were the following:³

- Adaptability is related to sustainability and durability, in both educational and workforce settings.
- An emphasis on mindsets in addition to skill sets has the potential to be transformative in education.
- Companies and educational institutions must keep the communication lines open about existing and anticipated company needs, especially nontechnical skills.
- A healthy innovation ecosystem requires diverse inputs, and flexibility and adaptability are one way of achieving diversity.
- To what extent can best practices in building or understanding adaptability be generalized from one industry to others?
- Which skills can be built in a self-guided way, and which need support?
- How can experiential learning be structured to enhance adaptability?
- How can measurement systems for adaptability be improved and made more affordable and accessible to more organizations?
- How does adaptability differ from and relate to resilience? For example, when is the persistence of adaptations desirable?
- What are the best ways to identify and share best practices?
- Which adaptability skills are best developed in K–12 education and which in higher education or later?
- Has anyone studied the effect of gender on adaptability? Can adaptability programs be used to retain women engineers?

K–12 EDUCATION AND OUT-OF-SCHOOL LEARNING

The second lightning round, on the potential of K–12 education and out-of-school learning to enhance adaptability, was moderated by Betsy Brand, executive director of the American Youth Policy Forum.

Brynt Parmeter, director of workforce development at NextFlex, described its program of immersing high school students in the world of advanced manufacturing and entrepreneurship through project-based learning activities. He noted that this emphasis on adaptability and problem solving has proven especially effective with women and underrepresented minority students as they gain confidence and experience.

³ This list is the rapporteurs’ summary of the main points made by individual speakers during the general discussion. The statements have not been verified or endorsed by the National Academies of Sciences, Engineering, and Medicine.

The Made Right Here program is project-based training with learning modules that emphasize iteration, innovation, and creativity. According to the organization's CEO Bernie Lynch, this "makership," rather than apprenticeship activity, helps students articulate an economic value proposition that allows them to find jobs that will pay them to do what they want to do.

"New-collar jobs" that require a high school diploma but not necessarily a four-year degree call for the same adaptability skills as those needed for other professions, according to Grace Suh, director of education and corporate citizenship at IBM. IBM's P-TECH program (Pathways in Technology Early College High Schools) aims to develop problem solving, critical thinking, communication, leadership, and adaptability. "Those are the kinds of skills we're trying to foster in these young people so that when they graduate they are ready for jobs," said Suh.

David Greer, senior vice president and chief programs officer for Project Lead The Way, argued that since every job has technical components, all students need to learn to be adaptable. The program engages students in hands-on learning in three pathways: computer science, engineering, and biomedical science, with activities at all educational levels, beginning in kindergarten.

Schools are critical in building the skills associated with adaptability, but school-aged children spend 80 percent of their waking hours outside of school, noted Chris Smith, executive director of Boston After School & Beyond. Afterschool and summer programs therefore provide a tremendous opportunity to foster adaptability.

Working in teams, the workshop participants again articulated their takeaways from the lightning round⁴:

- Much learning takes place outside formal educational environments, and social support systems could strengthen such out-of-the-classroom learning.
- New terms such as *maker professionals* and *new-collar jobs* can reflect the sense of agency and identity that supports adaptability.
- Resilience and empowerment help create the confidence and flexibility that underlie adaptability.
- Sharing examples of best practices and successful activities from schools and businesses will accelerate the changes that are needed.
- A resilient system has layers of support and supporters so that no one institution or person acts as a gatekeeper.
- A better societal support system, such as a better healthcare system, could support flexibility and creativity in the workplace.
- The development of confidence can enhance an employee's ability to adapt.

In this lightning round, the panelists also reflected on what they had heard both from each other and the participants:

- An overemphasis on testing can teach students that the exploration and flexibility needed for adaptability are a liability.
- Giving students the opportunity to work in teams can provide them with the confidence and inspiration they need to excel as individuals.
- Public-private partnerships can break down silos and make use of differing expertise.
- Meaningful exposure to workplace settings, not just touring a plant or facility, can help students develop the skills they will need in those settings.
- No one program or approach can meet the need for adaptability, though there may be common elements to programs that are successful.

⁴ This list is the rapporteurs' summary of the main points made by individual speakers during the general discussion. The statements have not been verified or endorsed by the National Academies of Sciences, Engineering, and Medicine.

POSSIBLE NEXT STEPS SUGGESTED BY PARTICIPANTS

In the final session, the panel moderators summarized the messages they heard during the workshop as well as participants' comments on opportunities and gaps in efforts to address changes in both the business model and the nature of work that call for adaptability.⁵

Individuals

- Identifying the value proposition of adaptability for individuals could clarify priority actions.
- Activities and programs to develop other skills could be designed to have a side benefit of helping individuals become more adaptable.

Companies

- Identifying the value proposition of adaptability for companies could clarify priority actions.
- Changing the language used to describe particular types of jobs and workers to remove negative connotations would reduce barriers to adaptability associated with those jobs.
- New terms such as *maker professionals* and *new-collar jobs* reflect the sense of agency and identity that supports adaptability.
- Strong leadership can create a culture of adaptability and help employees reach their full potential.
- Sharing examples of companies' best practices and successful activities in training their employees to meet workplace changes will accelerate the changes that are needed.

Researchers and Data Analysts

- Improved, more accessible, and less expensive analytics of adaptability could drive training efforts, data gathering, and a broader adaptability agenda.
- Further study of individual, team, and organizational adaptability can identify their commonalities and differences.
- A tool that can measure adaptability across multiple sectors and regions could provide data that can lead to continuous improvements in workforce skills.

Educators

- Establishing appropriate roles for K–12 education, higher education, and out-of-school activities in fostering adaptability could benefit students at all levels.
- Partnerships among educational institutions, companies, and government can focus attention on adaptability across sectors.
- Connecting education to real-world challenges could help develop skills needed in the modern workplace.
- Sharing examples of best practices and successful activities from K–12 and higher education will accelerate the changes that are needed.
- Educational institutions at all levels need to develop cultures that foster change.

General

- Providing students with information about educational pathways and workforce opportunities can help them make good decisions about educational and career options.
- Champions for change can help focus the attention of policymakers, business leaders, and educators on the need for adaptability.
- Policy needs to take into account that no one program or approach can meet the need for adaptability, though there may be common elements to programs that are successful.

⁵ This list is the rapporteurs' summary of the main points made by the panel moderators in the final session and by individual speakers earlier in the workshop. The statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

DISCLAIMER: This Workshop Highlights was prepared by Kenan Jarboe as a factual summary of what occurred at the workshop. The statements made are those of the rapporteur or individual workshop participants and do not necessarily represent the views of all workshop participants; the planning committee; or the National Academies of Sciences, Engineering, and Medicine.

SPONSORS: The workshop was directly supported by contributions from GE, the US Department of Energy Advanced Manufacturing Office, EY, Allied Minds, Dassault Systèmes, and Nicholas Donofrio. The workshop also relied on past contributions for the *Making Value for America* foundational report from the Robert A. Pritzker Family Foundation, Gordon E. Moore, Cummins, Boeing, IBM, Rockwell Collins, Xerox, Qualcomm, and gifts to the National Academy of Engineering Fund by Jon Rubinstein and Edward Horton.

For more information, visit <https://www.nae.edu/Activities/Projects/mdi/167920/176753.aspx>. *Adaptability of the US Engineering and Technical Workforce: Proceedings of a Workshop* can be purchased or downloaded from the National Academies Press, 500 Fifth Street NW, Washington, DC 20001; (800) 624-6242; <http://www.nap.edu>.

National Academy of Engineering

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org