Building the Foundational Skills Needed for Success in Work at the Human-Technology Frontier

Executive Summary

Joyce Malyn-Smith, Ed.D.
David Blustein, Ph.D.
Sarita Pillai, M.B.A.
Caroline E. Parker, Ed.D.
Ellen Gutowski, M.A.
A. J. Diamonti, M.A.

EDC Learning transforms lives.

COLLEGIUM BOSTONIENSE FUND. MDCCCLXIII

stelar
STEM Learning and Research Center

Suggested citation:
Malyn-Smith, J., Blustein, D., Pillai, S., Parker, C. E., Gutowski, E., & Diamonti, A. J. (2017). *Building the foundational skills needed for success in work at the human-technology frontier.* Waltham, MA: EDC.

Photo credits:
iStockPhoto

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1312022 and DRL-1614697. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Education Development Center (EDC), is a global nonprofit that advances lasting solutions to improve education, promote health, and expand economic opportunity. Since 1958, we have been a leader in designing, implementing, and evaluating powerful and innovative programs in more than 80 countries around the world. Visit www.edc.org

Executive Summary

The proliferation of new technologies has changed the way we live, learn, and work. Although the future of work is unclear, experts envision a new machine age, where technologies (sensors, communication, computation, and intelligence) will be embedded around, on, and in us; where humans will shape technology, and technology will shape human interaction; and where technologies and humans will collaborate to discover and innovate. In short—the Human-Technology Frontier.

Without question, the U.S. workforce will need a new set of skills and competencies to succeed in the future work environments on this frontier—which feels like it grows closer with each new technological advance—and to maintain global leadership in the 21st century. To ensure that the U.S. workforce is future-ready, our society will need to address new challenges related to education for workforce development, economics, equity, and ethics. As our society works to understand and identify strategies to overcome these complex and interrelated challenges, we will need to answer several questions:

- What does work look like at the Human-Technology Frontier, and what are the skill sets workers will need to succeed in those work environments?
- What can we do to prepare today's students to succeed in work at the Human-Technology Frontier?
- What steps can we take to make this happen?

Informed by research and thought leaders in the field, this paper presents examples of the best current thinking on work at the Human-Technology Frontier and the types of skills, knowledge, and dispositions that people will need to create and innovate in future workplaces. It discusses the psychology of work and issues of social stability drawn from implications of what work will look like at the Human-Technology Frontier, reviews research on career development that will guide individuals as they make life and career pathway decisions, and emphasizes the importance of developing strong foundations for STEM careers in pre-K–12 education. The paper also reviews the social implications and complex challenges facing work at the Human-Technology Frontier and describes the unique strengths of the NSF ITEST (Innovative Technology Experiences for Students and Teachers) program as a model and mechanism to nurture a future-ready workforce. The paper closes with key policy levers that can greatly contribute to the development of a robust future STEM workforce, help ensure the well-being of that workforce, and support and sustain a strong innovation economy for our country.

Highlights

Work at the Human-Technology Frontier: In brief, we found that work environments at the Human-Technology Frontier will likely be characterized by the following:

- A predominance of dynamic, interdisciplinary teams
- A focus on data
- Ubiquitous computational, engineering, and design thinking
- Convergence and a focus on life sciences
- Increased use of artificial intelligence and machine learning, with blurred boundaries between humans and machines
- Heightened attention to cybersecurity
- An emphasis on problem-based learning
- Increased focus on continuous life-long learning
- Increased attention to ethical considerations that promote innovation and productivity while also ensuring the well-being of individuals and societies

The optimal new type of worker will be curious, self-directed, and resilient, willing to be disruptive and innovative, while also being cooperative and interpersonally competent. They will think outside the box; be willing to risk failure; and lead dynamic, cross-disciplinary teams to consensus. Their work will be characterized by insight, interpretation, diligence, persistence, and cooperation.

The Psychology of Working and Career Development: The importance of work to society, why work is critical to human identity, and how youth develop their work identities are described through two theories that help us understand how we might cultivate a future-ready workforce and help people access stable and decent work:

1. The Psychology of Working Theory describes ways in which work itself may provide for core human needs that are integral to our well-being.
2. Social Cognitive Career Theory illustrates the process of career development that begins early in life, evolves iteratively and developmentally, and is impacted by the contexts within which people live, learn and work. Psychosocial factors of self-efficacy, proactive personality, work volition, career adaptability, and critical consciousness help to shape STEM Career Development in K–12 Education.

Value and Contributions of K–12 STEM Education Programs and ITEST: Supporting early career development, K–12 STEM education programs, such as NSF's ITEST, contribute to youth's abilities to build the skills and competencies needed for work at the Human-Technology Frontier and prepare them to participate fully in the future world of work. ITEST projects, for example, provide students with the following opportunities:

- Use real-world STEM tools and procedures to understand how information and engineering technologies are used to conduct routine tasks and solve problems in scientific laboratories and workplaces
- Develop the foundational concepts and skills in mathematics, science, technology, and engineering needed for STEM careers, which increase students' access to higher-level STEM education options and career opportunities
- Interact with scientists, engineers, technologists, and other STEM professionals who visit classrooms, help students conduct field studies, and serve as mentors to students as they work on real-world problems

ITEST projects also provide professional learning experiences for teachers, which enable them to build the STEM competencies of their students.

As a community of thought leaders in the field of STEM education, ITEST principal investigators have also addressed STEM workforce education challenges, yielding, for example, the STEM Workforce Education Outcomes Model, which articulates examples of indicators for skills, knowledge, dispositions, and actions for both STEM content outcomes and STEM career outcomes.

Policy Levers for the Development of a Robust STEM Workforce: As we look to the horizon of the world of work and its implications for future generations of workers, we have identified a set of key policy levers that will contribute to the development of a robust future STEM workforce, help ensure the well-being of that workforce, and support and sustain a strong innovation economy for our country:

- **Invest early in STEM learning:** To move the needle, a greater emphasis is needed on STEM career development programs, such as ITEST, in pre-K–12 classrooms. By age 13, students are already making preliminary educational decisions that will impact their career trajectories. These programs must provide STEM experiences and adequate resources to address early on the potential inequalities that restrict participation in STEM careers; nurture students' dispositions (e.g., diligence, persistence, cooperation); and develop their interests in STEM, thereby, motivating them to explore STEM career trajectories leading to success in work at the Human-Technology Frontier.

- **Act now to ensure social stability in the machine age:** To broaden participation in STEM and build a future-ready workforce, more research and dialogue among policymakers, education and workforce development specialists, researchers, and technical and social scientists, from both the public and private sectors, are needed to develop programs, approaches, and strategies that address social stability challenges associated with advances in automation at the Human-Technology Frontier.
- **Carefully consider the ethical, safety, and security implications of the Human-Technology Frontier:** As emerging technologies move toward broader deployment, technologists, researchers, policymakers, and ethicists have raised concerns about unintended consequences of widespread adoption of these technologies. Federal agencies and departments, private foundations supporting workforce and educational innovations, and business leaders have several potential roles to play in this regard, including the following:
    - Investing in the development of ethics-related curricula and professional development for students and practitioners in K–12 and in academia
    - Supporting the work of researchers and developers to ensure that (1) technological systems are governable as well as open, transparent, and understandable; (2) they can work effectively with people; and (3) their operation will remain consistent with human values and aspirations
- **Engage research and practice leaders within federal agencies and institutions to engineer innovation and conduct research in STEM workforce education:** To spread quickly and scale successful workforce education for the Human-Technology Frontier, it is imperative to connect those working on the cutting-edge of shaping K–20 STEM education with those creating scientific and technical innovations through our nation's research initiatives. Together, these interdisciplinary teams can create breakthroughs in thinking that will dramatically affect the designs of STEM workforce education for success at the Human-Technology Frontier. As a body, these teams of thought leaders can contribute extraordinary insight and expertise to address the career and workforce development issues raised in this paper, including the effects of scientific discovery and automation; ethical implications; and the importance of developing the foundational knowledge, skills, and dispositions early at the K–12 levels.
- **Share findings broadly to leverage change:** The advances from programs such as ITEST and other similar initiatives need to be disseminated to the broader science education and career development communities so that

evidence-based best practices can be utilized to improve STEM workforce education experiences for all. This includes sharing advances with a broad, inclusive set of STEM workforce education stakeholders, which begins with the public at large and includes K–12 education, business, and industry leaders, as well as those engaged in preparing STEM and STEM-enabled workers in career and technical education programs, community colleges, trade schools, and trade displaced worker programs.

Conclusion

We believe that the STEM community, workforce development leaders, and government agencies and foundations serving the public good must be part of the solution by intentionally facing the growing crisis of access to stable and decent work at the Human-Technology Frontier. The time is right for thoughtful deliberations about the optimal use of federal policy and national funding levers as drivers of adaptive change in the workforce challenges that face our nation. The Human-Technology Frontier holds the promise of great economic growth and social progress, if industry, the federal government, and the public work collaboratively and give careful thought to both the potential gains and the risks that are emerging at that Frontier. By intentionally and systematically investing resources in understanding and intervening in the changes occurring at the intersection of human workers and technology, we are confident that our national institutions can play a major role in creating an inclusive pathway for our youth to find meaning, purpose, and sustained livelihoods in their adult work lives. Forward progress, however, requires action.

EDC
43 Foundry Avenue
Waltham, MA 02453

edc.org

Boston | Chicago | New York | Washington, D.C.