New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION


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

Joyce Malyn-Smith[1], David Blustein[2], Sarita Pillai[3], Caroline E. Parker[4], Ellen Gutowski[5], A. J. Diamonti[6]

Abstract

Around the globe the world of work is rapidly changing, driven by multiple levers including machine learning, artificial intelligence, the internet-of-things, and robotics [1]. To address the scientific and technical challenges of the future of work and productivity, the U.S. National Science Foundation (NSF) proposes a bold initiative, Work at the Human-Technology Frontier: Shaping the Future. The NSF initiative is spurring the interdisciplinary science education and teaching research needed to maximize the potential success of individuals in the global, technology-driven workplace of the future. In this session, the authors will present findings from their report, "Building the foundational skills needed for success at work at the human-technology frontier". Building on the NSF's initiative encouraging research on the future of work, the report explores the future of scientific and other work, the importance of work for social stability and human fulfilment, the challenges associated with broadening participation in future work to communities traditionally underrepresented in science, the psycho-social factors affecting career development at the Human-Technology Frontier and the importance of early science education interventions. It shares current thinking about skills and knowledge needed for success in those emerging work environments drawn from both existing literature and interviews with future forward thinkers working at today's Human-Technology Frontier. The paper closes by proposing policy levers for the development of a robust STEM workforce.

Keywords: Workforce, Technology, STEM, Future, Education, Careers

Findings

Work at the Human-Technology Frontier: In brief, we found that work environments at the Human Technology Frontier will likely be characterized by: a predominance of dynamic, interdisciplinary teams; a focus on data; ubiquitous computational thinking, 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; and increased attention to ethical considerations that promote innovation and productivity while also ensuring wellbeing 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; think outside the box and risk failure; and lead dynamic, cross-disciplinary teams to consensus [2]. Their work will be characterized by insight, interpretation, diligence, persistence, and cooperation [3].

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 ways we might cultivate a future-ready workforce and help people access stable and decent work: The Psychology of Working Theory helps us understand ways in which work itself may provide for core human needs which are integral to our wellbeing [4]; 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 [5].

[1] Education Development Center, Inc., United States
[2] Boston College, United States
[3] Education Development Center, Inc., United States
[4] Education Development Center, Inc., United States
[5] Boston College, United States
[6] Boston College, United States

Psychosocial factors of Self-Efficacy, Proactive Personality, Work Volition, Career Adaptability and Critical Consciousness help to shape STEM Career Development in K–12 Education [6].

Value and Contributions of K-12 STEM Education Programs and Innovative Technology Experiences for Students and Teachers (ITEST). Supporting early career development, K-12 STEM education programs like 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 [7]. ITEST projects, for example, help students:

- 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
- And provide professional learning experiences for teachers that enable them to build the STEM competencies of their students [8].

Ethics at the Human-Technology Frontier: Increasingly, researchers and industry stakeholders are turning their attention to ethical implications and potential risks facing humanity, particularly existential risk from advanced artificial intelligence and other technologies. Technologies are not mere artifacts. They are social, cultural, and economic phenomena that cannot merely be deployed but must be integrated into society, thereby fundamentally changing society. Emerging technologies at the Human-Technology Frontier include, but are not limited to, information technology, genomics, biotechnology, synthetic biology, nanotechnology, personalized medicine, stem cell and regenerative medicine, robotics, and geoengineering. Organizations such as the Future of Life Institute, its founders—including MIT cosmologist Max Tegmark and Skype co-founder Jaan Tallinn—and its board of advisors, which includes cosmologist Stephen Hawking, are mobilizing to tackle these kinds of challenges. The many hotly debated topics in the field include ensuring that future artificial intelligence and technology systems are robust and immune to hacks, growing our national prosperity through automation while still preserving people's resources and purpose, realizing what set of values should align with work at the Human–Technology Frontier, and what legal and ethical status artificial intelligence should have. The implications of artificial intelligence, and its ability to mimic human intelligence, may require more attention on a federal level [9].

Recommendations

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 can greatly contribute to the development of a robust future STEM workforce, help ensure the wellbeing 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 that start 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 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 as well as 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 investing in the development of ethics-related curricula and professional development for students and practitioners in K–12 and in academia, and supporting the work of researchers and developers to ensure that technological systems are governable; that they are open, transparent, and understandable; that they can work effectively with people; and that 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 involve those 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 designs of STEM workforce education for success at the Human-Technology Frontier. As a body, these teams of thought leaders can bring 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 SETM workforce education stakeholders, which begins with the pubic 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 need to be part of the solution by intentionally facing the growing crisis in 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.

References

[1] Frey, C.B., & Osborne, M.A. (2013). The future of employment: How susceptible are jobs to computerization? Technological Forecasting and Social Change, 114.
[2] Howard, J. (2017, April 21). Jeremy Howard: Will artificial intelligence be the last human invention? [Video file]. Retrieved from http://www.npr.org/2017/04/21/524702525/jeremy-howard-will-artificial-intelligence-be-the-lasthuman-invention?
[3] National Academy of Sciences. (2017). Information technology and the U.S. workforce: Where are we and where do we go from here? Washington, DC: The National Academies Press.
[4] Holland, J. L. (1997). Making vocational choices: A theory of vocational personalities and work environments, 3rd ed. Odessa, FL: Psychological Assessment Resources.
[5] Huston, A. C., & Bentley, A. C. (2010). Human development in societal context. Annual Review of Psychology, 61, 411–437, C1. http://dx.doi.org/10.1146/annurev.psych.093008.100442
[6] Katz, L. F., & Krueger, A. B. (2016). The rise and nature of alternative work arrangements in the United States, 1995-2015. Retrieved from http://scholar.harvard.edu/files/lkatz/files/katz_krueger_cws_v3.pdf
[7] Education Development Center. (2012). ITEST engineering model: Building a better future for STEM learning. Waltham, MA: EDC-Author.
[8] Reider, D., Knestis, K. & Malyn-Smith, J. J. (2016). Workforce education models for K–12 STEM education programs: Reflections on, and Implications for, the NSF ITEST program. Journal of Science Education and Technology, 26(6), pp. 847–858.
[9] Stiglitz, J. E. (2015). Rewriting the rules of the American economy: An agenda for growth and shared prosperity. Roosevelt Institute. Retrieved from http://communitywealth.org/sites/clone.community-wealth.org/files/downloads/report-stiglitz.pdf