Preparing Technicians for the Future of Work

A Framework for a Cross-Disciplinary STEM Core

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CORD Leading Change in Education

About the Project

With a focus on two-year colleges, the National Science Foundation Advanced Technological Education (NSF ATE) program supports the development of innovative approaches for educating highly skilled technicians for the STEM-enabled industries that drive the nation's economy.

Preparing Technicians for the FUTURE OF WORK

The NSF ATE project Preparing Technicians for the Future of Work (DUE 1839567) enables regional collaboration between community college educators and industry partners, within and across disciplines, on the transformation of technical associate degree programs.

CORD Leading Change in Education

The Center for Occupational Research and Development (CORD), a national nonprofit organization, partners with educators, employers, states, and federal agencies to prepare learners for success in college and careers.

SUGGESTED CITATION

Center for Occupational Research and Development. "A Framework for a Cross-Disciplinary STEM Core." July 2021.

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Today's Evolving Workplace

The global workplace is evolving right before our eyes. Advancements driven by technologies such as machine learning, artificial intelligence, the Internet of Things, and robotics are transforming existing industries and creating new ones at an unprecedented pace. The World Economic Forum predicts significant disruption in the jobs landscape over the next four years. As many as 85 million current job roles may be displaced while more than 97 million new roles could emerge.[1] Nearly all jobs will change. Many of the emerging jobs will be enhanced by technologies that can collaborate with humans to enrich lives and workplaces in what the National Science Foundation (NSF) describes as the "future of work at the human-technology frontier."[2] To harness the convergent research integrating future work, future technology, and future workers, NSF aims "to catalyze the interdisciplinary S&E [science and engineering] needed to understand the benefits as well as the risks of new technologies" to humans and their work.[3]

Many workers in this increasingly technology-driven era, dubbed Industry 4.0, will not fill conventional jobs but what have been called "superjobs," an emerging job category that will require high levels of human skills. According to Deloitte:

> The use of artificial intelligence (AI), cognitive technologies, and robotics to automate and augment work is on the rise, prompting the redesign of jobs in a growing number of domains. The jobs of today are more machine-powered and data-driven than in the past, and they also require more human skills in problem-solving, communication, interpretation, and design. As machines take over repeatable tasks and the work people do becomes less routine, many jobs will rapidly evolve into what we call "superjobs"—the newest job category that changes the landscape of how organizations think about work.[4]

Burning Glass and the Business Higher Education Forum, in *The New Foundational Skills of the Digital Economy*, describe this workplace transformation:

> As jobs come to be redefined by new modes of work, the result is a hybridization that mashes together skills from disparate domains and demands greater breadth and flexibility of the workforce.[5]

U.S. industries face a serious challenge in attracting, upskilling, and retaining an appropriately skilled workforce that is prepared for Industry 4.0. Deloitte and the National Association of Manufacturers identified a "burgeoning skills mismatch between the increasing digital skills that employers need and those of the existing manufacturing workforce."[6] This changing skill set "spans design to service, production to operations. Skills like programming, critical thinking, and knowledge of computers are becoming table stakes for many production floor jobs. . . . Robot teaming coordinators, digital twin engineers, and predictive supply network analysts are examples of the new roles cropping up in manufacturing facilities."[7]

Many observers note the urgency of correcting this mismatch in skills. The National Science Board, for example, calls for the United States to increase the number of STEM associate-degreed technicians:

> Our skilled workforce is *foundational* and *essential* to U.S. leadership in science and engineering (S&E) and the economic prosperity and security that flow from it. Yet on a near daily basis, headlines emphasize that we are not doing enough to develop and sustain our nation's human capital. For the United States to compete and thrive in today's S&E-driven world, our country must nurture a workforce that can lead in every phase of research and development (R&D), from discovery to innovation to product realization and sustainability. A key component of this workforce is the Skilled Technical Workforce (STW), the roughly 17 million workers who use S&E expertise and technical knowledge in their jobs but who do not possess a bachelor's degree.[8]

Now Hiring: Cross-Disciplinary Workers

The evolving workplace calls for cross-disciplinary workers who can function well in the diverse platforms and systems that drive multiple sectors. In the very near future, technicians will need skill sets that *cross* industries and sectors and support both core and advanced STEM skills.

How will those versatile, cross-disciplinary technicians be trained? The answer represents a paradigm shift for institutions that provide technician education. Technician educators must be empowered to integrate multiple disciplines into existing programs and develop new programs that support emerging disciplines and occupations. This shift is a necessary response to the rapid adoption of technologies associated with Industry 4.0 — autonomous robots, the Internet of Things, simulation, big data analytics, augmented reality, systems integration, cloud computing, additive manufacturing, and cybersecurity, among others.

Because community and technical colleges provide most of the preparation of America's technicians, a big part of the daunting task of keeping programs relevant and responsive to today's workplace will fall to them. To stay competitive, colleges must transform associate degree programs to produce technicians who can meet the new expectations of the workplace. That transformation will involve components such as broader delivery methods, content and experiential learning that mirrors the workplace, instructional methods that support guided self-learning, integrated micro-learning technologies, alignment with industry needs and credentials of value, credit for prior learning, robust learn-and-earn models, and a renewed energy in recruiting underrepresented populations.

> "The evolving workplace calls for cross-disciplinary workers who can function well in the diverse platforms and systems that drive multiple sectors."

Future-Proofing the American Workforce

Industry 4.0's transformation of the workplace means America's technicians must be able to navigate, interact with, and troubleshoot increasingly complex processes resulting from the convergence of cyber and physical systems. Considering these evolving workplace demands, are there specific knowledge and skill areas that could future-proof STEM technicians? To answer this question, *Preparing Technicians for the Future of Work* conducted a series of research activities designed to catalogue the foundational knowledge and skills identified as essential for future STEM technicians.

The project team conducted workplace interviews of technicians, technician supervisors, and middle managers to learn how technology acceleration is impacting their jobs:

> "One of our core operating principles is making minor and major decisions based on factual information. We already push a great deal more data down to the floor level to make it both visible and actionable by floor-level employees. We anticipate the reliance on data for worker actions to continue to increase in the future."

> "We're constantly installing new equipment. With new lines comes new technology—new robotics, different/more/better communication systems. New technology is a constant."

> "We've had 14 of our technicians migrate into engineering. What we do every day involves the skills of an engineer."

Identifying the Components of the Cross-Disciplinary STEM Core

To further quantify the impact of advancing technologies on STEM skill requirements, the project gathered data from national and regional convenings of academic partners and industry leaders representing a wide range of technologies. Participants served as thought partners in framing strategies that could transform technician education to ensure ongoing regional competitiveness. These efforts resulted in the identification and categorization of cross-disciplinary topics that educators and technician employers identified as essential skill areas for associate degree technician programs, regardless of industry sector. Participants also noted that within this new cross-disciplinary core for STEM technicians, prioritization of the skills will be based on regional industry needs.

This cross-disciplinary STEM core consists of three components: data knowledge and analysis, advanced digital literacy, and business knowledge and processes. (See Figure 1.) The project team recognizes that this list will not remain static but will need to adapt to keep up with technological advancements.

Figure 1. Components of the Cross-Disciplinary STEM Core

DATA KNOWLEDGE AND ANALYSIS	ADVANCED DIGITAL LITERACY	BUSINESS KNOWLEDGE AND PROCESSES
Manipulating and interpreting data to resolve issues and using Excel and other common software proficiently to accomplish tasks	Understanding digital communications and networking, cybersecurity, machine learning, sensors, programming, and robotics at a higher than introductory level	Understanding the value chain and business practices of an enterprise and applying principles of ethical adoption of new technologies
Analytics tools Computational thinking Data analysis Data backup and restoration Databases Data fluency Data life cycle Data management Data modeling Data storage Data visualization Query languages Spreadsheets Statistics	Artificial intelligence/ machine learning Automation/robotics Basic programming Cloud literacy Digital fluency Digital twins Edge computing Function block diagram programming Human-Machine Interface (HMI) Internet of Things (IoT) Network architecture Network communication Security controls	Business cycles Blockchain Communication Continuous process improvement Customer/stakeholder analysis Entrepreneurship Ethics Lean processes Supply chains Market trends Overall Equipment Efficiency (OEE) Return on Investment (ROI) Risk management Supply and demand Vertical and horizontal integration

These three core knowledge and skill areas are essential in today's workplace because they transcend narrow job specialization. Companies can no longer survive with technicians who know how to work with only one or two types of devices. As markets shift and companies adopt new technologies to keep pace, technicians must be able to move laterally to other jobs, learn new techniques, and work with new equipment. Those possessing the broader skills and knowledge found in the cross-disciplinary STEM core will be more flexible in the types of work assignments they can take on, and thus more valuable to employers and better situated for continued employment and promotion.

The main benefit of the cross-disciplinary STEM core is that it enables technicians to *adapt*. Possessing these core skills isn't just about filling jobs now. It's about empowering workers to navigate a complex employment environment involving job loss, job change, and the constant creation of new jobs.[9]

Adopting the Framework for a Cross-Disciplinary STEM Core

In today's work environment, the cross-disciplinary STEM core is essential, not only regionally but nationally and even globally. The question is, how can these skills be added to already full technical programs?

We believe the best strategy for adding the cross-disciplinary STEM core into associate degree programs is to integrate relevant lessons into existing courses rather than attempting to add new courses. This strategy would give colleges the flexibility to offer cross-disciplinary content prioritized by regional employers, without significant instructional disruption.

Integrated lessons help students see the wider perspective of content relationships.[10] For example, as students learn biotechniques for working in the biotech industry, they should also learn the fundamental concepts of cybersecurity and even entrepreneurship (along with other topics in Figure 1). This is best accomplished by integrating those concepts into existing biotech coursework in the context of potential work settings.

Figure 2 identifies actions for successfully integrating the cross-disciplinary STEM core into technical programs.

Figure 2. Adopting the Cross-Disciplinary STEM Core

Prioritize Topics

Invite industry advisors and employer partners to prioritize topics from each of the core foundational areas based on sector and regional priorities.

Determine Integration Points

Facilitate curriculum workgroups to determine appropriate models for integration of content into technical program instruction.

Develop Real-World Scenarios

Collaborate with industry advisors and employer partners to develop workplace scenarios on which to base instruction.

Provide Faculty Development

Offer opportunities for faculty to gain strategies for integrating the cross-disciplinary core.

Support Systemic Change

Promote cross-disciplinary collaboration and accumulation of skills across the college's STEM technical programs in alignment with employer demand.

The Time for Action Is Now

Today's prospects for technological advancement—and the resulting enhancements in the quality of life—are seemingly unlimited. The industries that thrive in the current environment will be the ones that stay abreast of technological developments, look to the future, and adapt quickly to changing conditions. Educational institutions, particularly two-year postsecondary institutions, must play an essential role in that process of adaptation by providing the necessary technicians. To ensure that those technicians are ready for the challenges of the workplace, education and industry must work together in aligning and continually updating technical programs.

The time for bold action on the part of instructional leaders, employer partners, and community college presidents is now. To advance adoption of the cross-disciplinary STEM core, we recommend the following actions.

Instructional Leaders and Faculty

- Inventory existing program content to determine alignment to the cross-disciplinary STEM core knowledge and skills.
- Form curriculum development workgroups to identify where the STEM core can be integrated into existing programs.
- Meet with employer partners to identify priority topics from the STEM core based on sector and regional needs.
- Determine how current courses can be enhanced by infusing lessons that integrate knowledge and skills from the STEM core.
- Provide professional development opportunities that equip faculty to integrate these concepts effectively.

Employer Partners

- Serve on an industry advisory committee to prioritize cross-disciplinary STEM core topics based on industry sector and regional needs.
- Collaborate with faculty to develop workplace scenarios and project-based learning experiences that help teach priority topics.
- Offer work-based learning experiences such as internships or apprenticeships to help students understand the STEM core in the context of work.

Community College Presidents

- Champion and adopt a systemic approach to preparing technicians for the future of work to meet identified regional needs.
- Promote cross-disciplinary collaboration and accumulation of STEM core skills across technical programs.
- Continuously engage employer partners in meaningful dialogue around existing and emerging workforce needs.

Get Involved

To encourage implementation of the framework, the *Preparing Technicians for the Future of Work* project offers tools for building partnerships with employers, identifying and prioritizing the core knowledge and skills required in your region, and integrating the cross-disciplinary STEM core into your technical programs.

For more information, please contact us at anderson@cord.org.

Endnotes

1 World Economic Forum, *The Future of Jobs Report 2020*, p. 5.

2 Hope Cotner, "Preparing for the Future of Work," *Community College Journal, 2019/2020*, p. 31.

3 National Science Foundation, *10 Big Ideas for Future NSF Investments*.

4 Volini, Erica, Jeff Schwartz, Indranil Roy, et al., "From Jobs to SuperJobs: 2019 Global Human Capital Trends." *Deloitte Insights, 2019*, p. 1.

5 Markow, Will, and Debbie Hughes. *The New Foundational Skills of the Digital Economy: Developing the Professionals of the Future*, Burning Glass/Business Higher Education Forum, 2018, p. 17.

6 Deloitte, *Navigating Disruption: Five Trends Influencing Tomorrow's Manufacturing Industry*.

7 Deloitte, *Navigating Disruption*.

8 National Science Board, *The Skilled Technical Workforce: Crafting America's Science & Engineering Enterprise*, 2019, p. 10.

9 Markow and Hughes, *The New Foundational Skills*, p. 17.

10 Center for Occupational Research and Development, *Teaching Contextually*.

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