



Imperative for Educating the Next Generation Robotics Technology Workforce

Holly Yanco (University of Massachusetts Lowell), Odest Chadwicke Jenkins (University of Michigan), Weisong Shi (University of Delaware), William Regli (University of Maryland) and Monica Anderson Herzog (University of Alabama)

The United States must urgently develop comprehensive educational and career training pathways in robotics across all levels — from K-12 through professional development — to build a skilled workforce capable of leading technological innovation and maintaining the nation's competitive edge in robotics and automation.

Why Robotics Education Matters

In the coming years, our world could be filled with robots working in our supply chains, autonomous vehicles on our roadways, robotic prostheses restoring physical function, and mobile robots assisting in the care of people with disabilities or who are aging. Advancements in robotics offer our society a chance to improve quality of life, reduce costs through enhanced productivity, and reshore manufacturing, as emphasized in the CCC Report: [A Roadmap for U.S. Robotics](#). However, one of the main challenges in unlocking the full potential of robotics is cultivating a thriving workforce with the necessary knowledge and experience.

Our nation must re-envision and rejuvenate educational and career training pathways into robotics, recognizing the significant overlap with AI and automation. To harness the potential of all citizens in driving U.S. innovation, we need to create diverse entry points into the field of robotics. This effort must span all educational levels: from K-8 to high school, through post-high school transitions, community colleges, universities, and continuing professional development. Strategic investments are needed to strengthen each sector and incentivize a focus on workforce success. By investing in robotics education and workforce development now, we can ensure that our nation remains at the forefront of technological transformation and continues to be a leading hub for scientific advancement.

Pathways in K-12

While some robotics education programs are available for primary and secondary students — e.g., Botball, FIRST, and VEX — these programs are typically offered as supplemental activities, often requiring additional costs and with the need to stay after school. As a result, these programs generally benefit only a narrow segment of students. Robotics education currently reaches only a small fraction of students and, in our national interest, must be made accessible to a broader segment of society. Simple robots, such as Arduino bots, can be as inexpensive as a graphing calculator and provide students with hands-on experience in introductory electrical and mechanical engineering, as well as coding and understanding robotic vision. Educational robotics programs exist for children as young as kindergarten, but they are not integrated into the curriculum. Sparking creative and intellectual interest around robots in our nation’s youth from an early age is critical to maintaining a workforce in robotics, and preserving the U.S.’s leadership in robotics and AI development.

Recommendation: Launch a national campaign to promote the integration of robotics education in the K-12 curriculum, providing frequent and in-depth exposure to robotics concepts and engineering.

Recommendation: Investment in professional development for teachers to prepare them to teach robotics in K-12 classrooms, expanding beyond programming and AI to include robotics concepts.

Establish National Training Centers for a Robotics Workforce

The broader manufacturing industry is currently challenged to find enough trained personnel to run plants in the U.S. In communities near existing plants, companies have invested in paid training-to-work programs where students have access to the latest technology. However, since these programs are generally localized to a few areas near existing plants, many potential workers have no knowledge of the jobs or access to training programs that lead directly to employment. To enable more manufacturing plants to relocate back to the U.S., we need to proactively provide training for a skilled workforce in more communities. Increasing the availability of these types of programs improves both the knowledge and interest of high school students that are attracted to hands-on professions.

Recommendation: Invest in the establishment of national training centers to prepare a robotics-ready workforce and ensure the responsible use of robot-controlled processes. These centers do not need to be wholly new or standalone organizations, but can add robotics capacity to existing institutions. One model is the [NSTC Workforce Center of Excellence](#), established under the CHIPS & Science Act of 2022, which was established to find workforce development solutions for the nation’s semiconductor industry.

Provide Shared Curriculum Resources

American colleges and universities remain the primary springboard for producing the “people and ideas” that drive the robotics innovation ecosystem. Higher education in the U.S. remains the beacon across the globe for educating robotics practitioners and generating transformative innovations. However, as noted in the final report of the National Security Commission on Artificial Intelligence (NSCAI), current academic structures pose a bottleneck to producing sufficient numbers of skilled robotics professionals. Programs like the [Michigan Robotics Major](#) aim to address this challenge by identifying core topics necessary for success in robotics careers and the robotics-driven workplace.

Many educational institutions lack the resources to develop robotics curricula and curricular resources on their own. Furthermore, a comprehensive set of materials must be made available to ensure all institutions can participate in creating pathways. We must create exemplary curricular resources in mechatronics — defined as the intersection of mechanics, electronics, and computing — including, but not limited to, CAD/CAM/simulation, PLC programming, CNC programming, flexible manufacturing systems, robotic equipment troubleshooting and maintenance, and human-robot interaction. Additional pathways should focus on integrating AI capabilities, including programming, statistics, and machine learning.

Recommendation: Incentivize educational institutions with robotics expertise to develop and share curricular resources and provide training for educators.

Establish Publicly Available Robotics Labs

Funding is needed for widespread, shared mechatronics hardware/software training labs that are accessible to high school and community college training programs. These labs would enable students to take workforce development courses in high school in collaboration with local community colleges, creating a skilled workforce attracting companies to expand existing facilities or establish new ones nearby.

Recommendation: Establish strategic and geographically distributed robotics labs as a national resource.

Create Public/Private Partnerships

To enable these pathways, public/private partnerships must play a central role. These partnerships can focus on collaboratively developing curriculum and learning materials, providing apprenticeship and internship programs for hands-on experience, and establishing publicly available national labs.

Recommendation: Establish programs that incentivize the robotics industry to partner with educational and nonprofit organizations to create shared resources required and increase the number of students prepared for robotics careers.

Pathways for Reskilling

The proliferation of robots and AI in the workplace will significantly alter the nature of new job creation, necessitating a mass transformation of the skills within the American workforce. The World Economic Forum estimates that over 50 percent of the global labor force may need reskilling by 2025. The US workforce is not prepared for this monumental shift, as many emerging jobs will involve AI and robotics. To avoid a massive talent shortage — potentially costing billions in lost productivity — significant funding and effort must be directed towards creating programs to reskill and upskill individuals in positions being automated or likely to be automated.

Recommendation: Establish a national program for reskilling the workforce impacted by robotics innovation. Outreach efforts should raise awareness of reskilling opportunities, especially for those whose jobs are likely to be automated or made redundant. Programs must include financial incentives and accommodate individuals requiring flexible scheduling.

Ensuring a Robotics-Ready Workforce

There is an urgent need to build a robotics-ready workforce. Unlike other computing fields, robotics involves physical systems, requiring skills to design, build, program, and repair these technologies. Investing in robotics education and workforce development will strengthen the economy and create middle-class jobs. Inaction risks undermining the nation’s ability to capitalize on robotics innovations and reducing U.S. global competitiveness.

*This quadrennial paper is part of a series compiled every four years by the **Computing Research Association (CRA)** and members of the computing research community to inform policymakers, community members, and the public about key research opportunities in areas of national priority. The selected topics reflect mutual interests across various subdisciplines within the computing research field. These papers explore potential research directions, challenges, and recommendations. The opinions expressed are those of the authors and CRA and do not represent the views of the organizations with which they are affiliated.*

This material is based upon work supported by the U.S. National Science Foundation (NSF) under Grant No. 2300842. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.