

## **Skill Sets Needed for Industrial Automation Careers**

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## **Skill Sets Needed for Industrial Automation Careers**

Industrial automation has a profound effect on the way we do work. Across the five major industry groups that employ more than 40 percent of all manufacturing employees, nearly three out of every four plants use advanced manufacturing technology<sup>1</sup>. A U.S. Census Bureau report notes that the yearly exports in the flexible manufacturing category (equivalent to industrial automation) were \$19.44B in 2006, a 10% jump from \$17.61B in 2005<sup>2</sup>. Monthly exports in the flexible manufacturing category were \$1.094B in August 2011, a 6% jump from \$0.9464B in August 2010<sup>3</sup>. This trend is likely to continue to increase as the manufacturing sector continues to transform to a high tech, high value added, less labor-intensive industry using advanced automated systems.

Workers who can create, maintain and operate these advanced automated systems are not easy to find. Even in troubled economic times, U.S. manufacturers have been experiencing a skills shortage in the area of industrial automation<sup>4</sup>. The aging of the manufacturing workforce exacerbates the problem. DeLong<sup>5</sup> notes that the oil and gas production industry can expect to lose more than 60 percent of its employees by 2010. As baby boomers age, the U.S. government, energy, education, manufacturing, health care, and aerospace and defense sectors will face very high rates of retirement.

A 2005 survey of 400 U.S. tool-and-die and machining companies, conducted by the National Tooling and Machining Association, found that skilled job openings equaled 4.7% of total skilled shop employment<sup>6</sup>. The shortage of entry-level technicians may be due to high school students' not being aware of potential benefits of careers in industrial automation. Harry Moser, president of AgieCharmile, a leader in the machine tool industry notes, "It's a question of perception. A technical A.S. and apprenticeship may not give you the prestige of a four-year degree, but will probably give you a better outcome." Frauenheim notes that young people need to understand that they can earn as much or more as a machinist or mechanic as they can as an office worker with a liberal arts bachelor's degree<sup>6</sup>.

Some common strategies used to prepare high school students for careers include career clusters (sequences of courses related to broad fields of work such as health sciences and engineering), magnet schools, career academies, and dual credit arrangements with two-year and four-year colleges<sup>7</sup>. All these approaches have value, but for helping students to learn about industrial automation, dual-credit arrangements are probably the easiest to implement. However, most dual credit offerings are general academic subjects, such as English, math and science. Some schools offer courses on particular types of technology, such as welding and robotics. There has been little emphasis on automated systems, perhaps because of limited access to the necessary technology at the high school level.

To assess industry workforce needs and skill sets in the area of industrial automation and to identify gaps and inefficiencies that affect students' ability to smoothly transition from high school to two or four-year college to jobs in industry, three two-year colleges in Texas who offer industrial automation and control degree programs invited over 150 of their industry partners to complete a survey on skill sets for industrial automation careers. The objective of this survey was to assess workforce needs and skill sets in the area of industrial automation. Of the 103 industry participants, 78 responded that their companies employ technicians or engineers who maintain

automated manufacturing systems as part of their job. Of these 78 participants, the majority (about 88%) indicated that their primary market segment/industry includes one of the following: oil & gas, automotive, semiconductor & electronics, energy storage and distribution, metals, or machine builder. Almost half (47%) indicated that their job level was manager or above; the rest were primarily either engineers or technicians.

Survey participants were asked to list the job titles of their company personnel who maintain automated manufacturing systems as part of their jobs. A wide variety of job titles were provided, including:

- Applications Engineer
- Automation & Process Control Engineer
- Automation Engineer
- Automation Specialist
- Automation Technician
- CNC Operator
- CNC Programmer
- Control Systems Engineer
- Control Systems Specialists
- Control Systems Technician
- Controls Engineer
- Electrician
- Electronics Technician
- Engineering Assistant
- Equipment Technician
- Field Service Tech
- Industrial Maintenance Technicians
- Instrument & Electrical Technician
- Instrument Technician
- Machinist
- Maintenance Technician
- Manufacturing Engineer
- Master Mechatronics Tech
- Measurement Technician
- Plant Technician
- Process Control Specialist
- Production Support Specialists
- Production Technician
- Production/Lease Operators
- Pump Operator
- Quality Technician
- SCADA Supervisor
- Service Technician
- Test Services Technician
- Welder

Industry participants were then asked to rate the importance of specific competencies within four areas related to industrial automation:

- electrical and electronic components and systems
- operation and control of automated systems
- maintenance and repair of electrical/electronics equipment
- maintenance and repair of mechanical equipment

These competencies were selected based on a review of syllabi used in teaching industrial automation subjects. Participants were asked to rate each competency as not important, somewhat important, important, or very important.

## Electrical and electronic components and systems

In the area of electrical and electronic components and systems, the following competencies were rated:

- a. Demonstrate knowledge of electrical power sources and their characteristics.
- b. Select and specify DC and AC power sources for various types of loads.
- c. Demonstrate knowledge of electromagnetic principles, operation of electromagnetic devices and their use in systems.
- d. Demonstrate knowledge of electric motors and generator types and applications.
- e. Select and specify electric motors, generators, and transformers.
- f. Perform measurements to determine electric motor characteristics.
- g. Demonstrate knowledge of electric safety devices (such as switches, fuses, and breakers) and proper grounding techniques.
- h. Select electronic devices for various applications using manufacturers' specification sheets and application notes.
- i. Employ heat-sinking techniques with electronic power devices.
- j. Use spectral analysis techniques to determine the make-up of pulse-waves (relative to Fourier analysis), and demonstrate knowledge of the effects of transmission line filtering and pulse distortion.
- k. Use engineering applications software for electrical/electronics network and systems analysis and simulation.

Figure 1 shows ratings for each of these competencies. The numbers indicate the percentage of industry participants who indicated that the competency is either *important* or *very important* for personnel who maintain automated manufacturing systems to have.

## Competencies: Electrical and Electronic Components and Systems

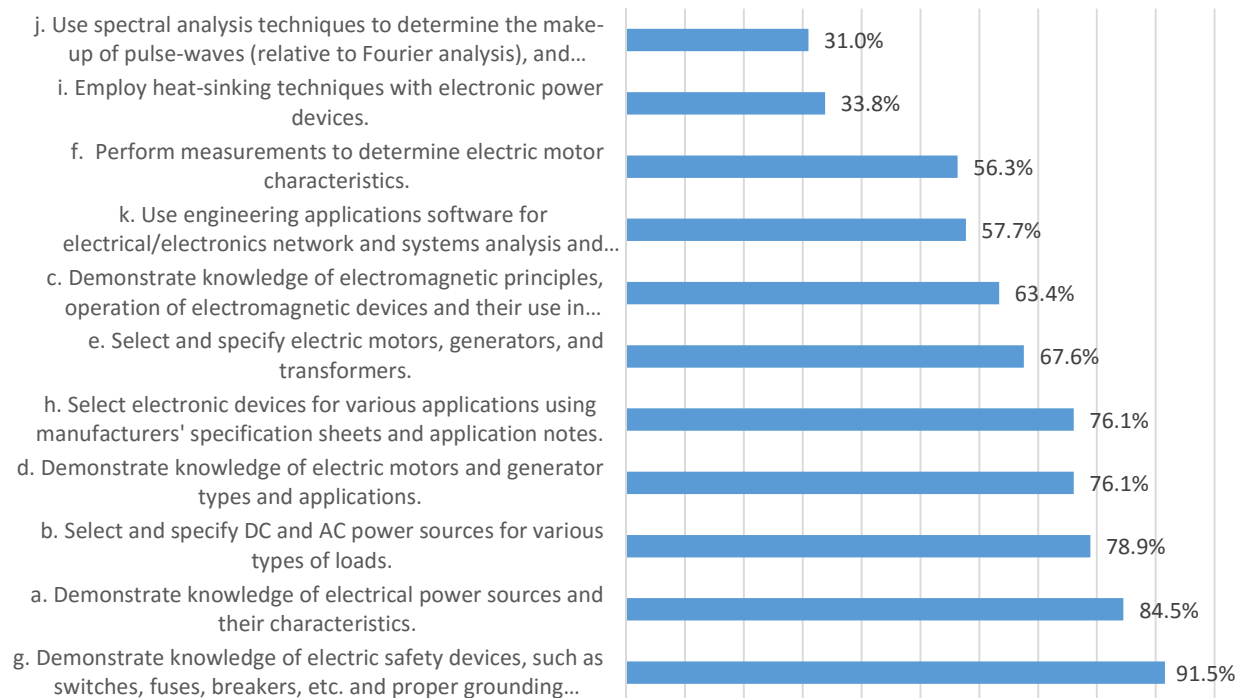


Figure 1. Electrical and Electronic Components - Competencies Considered to be Important or Very Important for Industrial Automation

### Operation and control of automated systems

In the area of operation and control of automated systems, the following competencies were rated:

- a. Demonstrate knowledge of open and closed loop control systems; evaluate their steady state and transient behavior; and use three-step controller techniques to modify the response for controlling a process.
- b. Evaluate and select electrical control system components such as circuit protection devices, sensors, relays, contractors, actuators, timers, counters, motors and various types of DC and AC drives.
- c. Test, adjust, and repair electro-mechanical equipment.
- d. Use wiring, connection, schematic, and ladder logic diagrams to troubleshoot control systems.
- e. Calibrate and maintain control equipment.
- f. Specify power needs and power service requirements for operation of automated systems.
- g. Operate automated systems.
- h. Maintain equipment maintenance and repair records.
- i. Select and install Programmable Logic Controller (PLC) hardware and software.
- j. Program PLCs for automated operations.

- k. Operate and maintain PLC systems.
- l. Select and evaluate hydraulic and pneumatic power devices such as pumps, valves, actuators, fittings, and hoses.
- m. Maintain, troubleshoot, and repair hydraulic and pneumatic control equipment and systems.
- n. Use a control system simulation application software package.
- o. Evaluate and select mechanical components of automated systems such as linear actuator, gear boxes, power transmission components, brakes and clutches.

Figure 2 shows the percentages of industry participants who indicated that these competencies are important or very important.

### Competencies: Operation and Control of Automated Systems

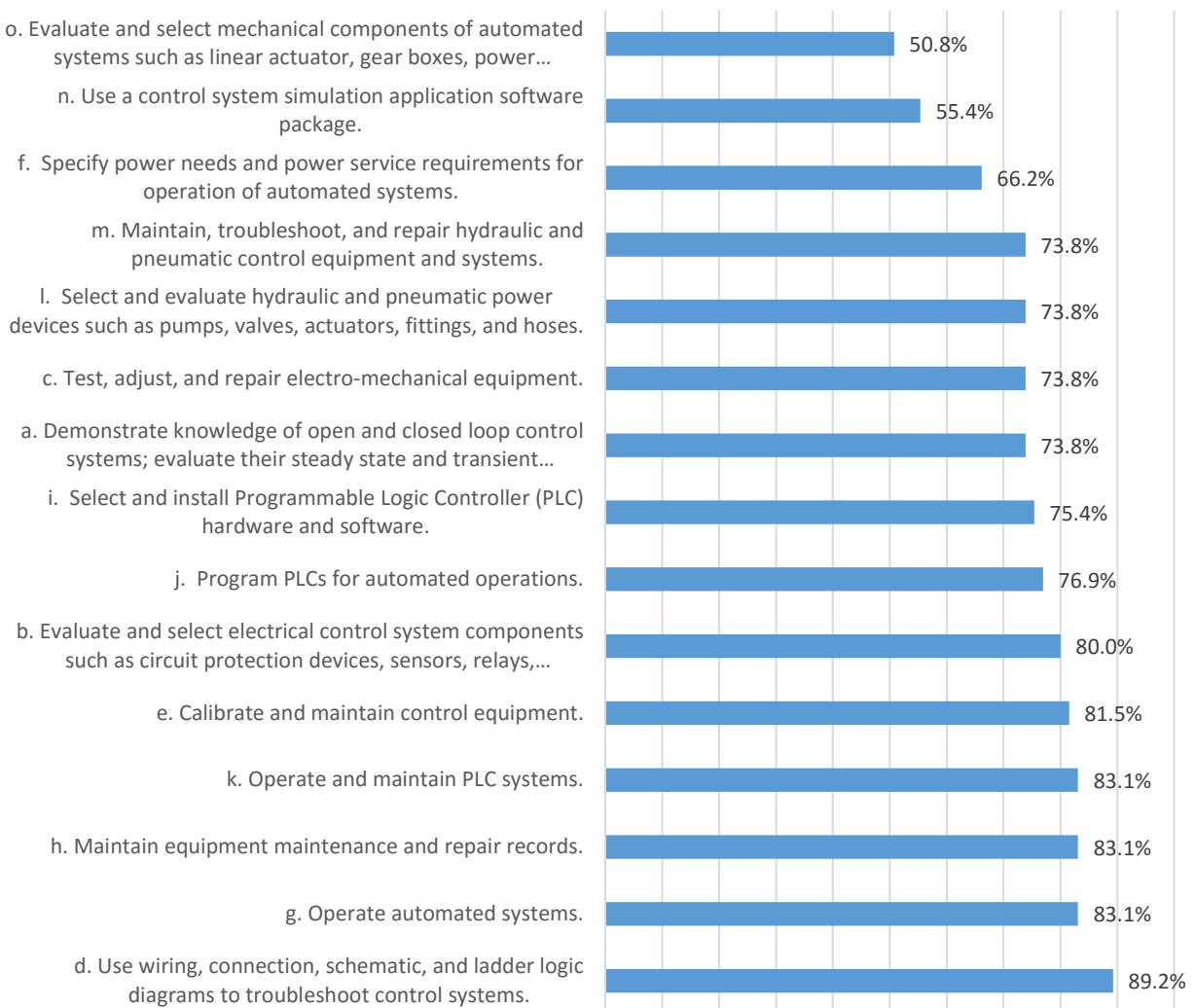


Figure 2. Operation and Control of Automated Systems - Competencies Considered to be Important or Very Important for Industrial Automation

## Maintenance and repair of electrical/electronics equipment

In the area of maintenance and repair of electrical/electronics equipment, the following competencies were rated:

- a. Employ safety procedures using manufacturer guidelines and industry and government standards when working with electrical/electronic equipment.
- b. Measure and interpret electrical quantities as compared to calculated values or manufacturers' specifications.
- c. Inspect, replace, repair, and construct cables and connectors.
- d. Demonstrate knowledge of effective troubleshooting techniques; use manufacturers' documentation and software, flow charts, and diagrams for efficient troubleshooting and repair of electrical/electronic system problems.
- e. Calibrate/adjust electrical equipment.
- f. Use manufacturers' documentation as a guide to performing scheduled maintenance of electrical equipment.
- g. Adjust and align electrical systems according to manufacturers' specifications.

Figure 3 shows the percentages of industry participants who indicated that these competencies are important or very important.

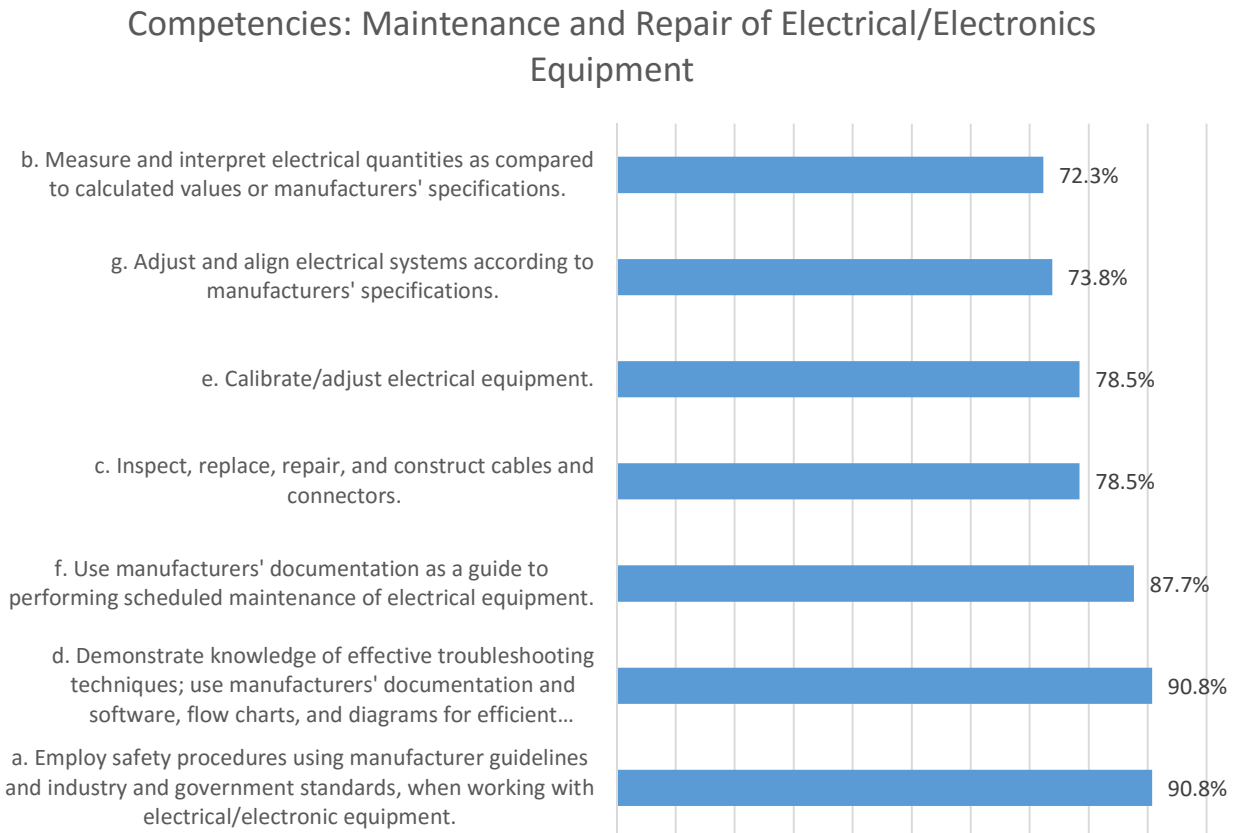


Figure 3. Maintenance and Repair of Electrical/Electronics Equipment - Competencies Considered to be Important or Very Important for Industrial Automation

## **Maintenance and repair of mechanical equipment**

In the area of maintenance and repair of mechanical equipment, the following competencies were rated:

- a. Use engineering drawings, wiring diagrams, schematics, and process diagrams to troubleshoot problems.
- b. Assemble or disassemble electrical and mechanical components and systems.
- c. Select and use appropriate tools needed for assembling and disassembling machine components.
- d. Employ safety procedures using manufacturers' guidelines and industry standards when working with mechanical devices & machinery.
- e. Select and use appropriate fasteners correctly.
- f. Demonstrate an ability to braze, weld, and solder for the purpose of repairing electrical, mechanical & hydraulic equipment.
- g. Select and order replacement machine parts.
- h. Maintain records of problems, maintenance procedures and repairs.
- i. Calibrate/adjust mechanical equipment.
- j. Use manufacturers' documentation to perform maintenance procedures.
- k. Demonstrate knowledge of the characteristics, functions, and application of various components used for mechanical power transmission.
- l. Demonstrate knowledge of characteristics, functions, and application of various components used for fluid power transmission.
- m. Demonstrate knowledge of characteristics, functions, and application of power transmission systems.

Figure 4 shows the percentages of industry participants who indicated that these competencies are important or very important.



## Competencies: Maintenance and Repair of Mechanical Equipment

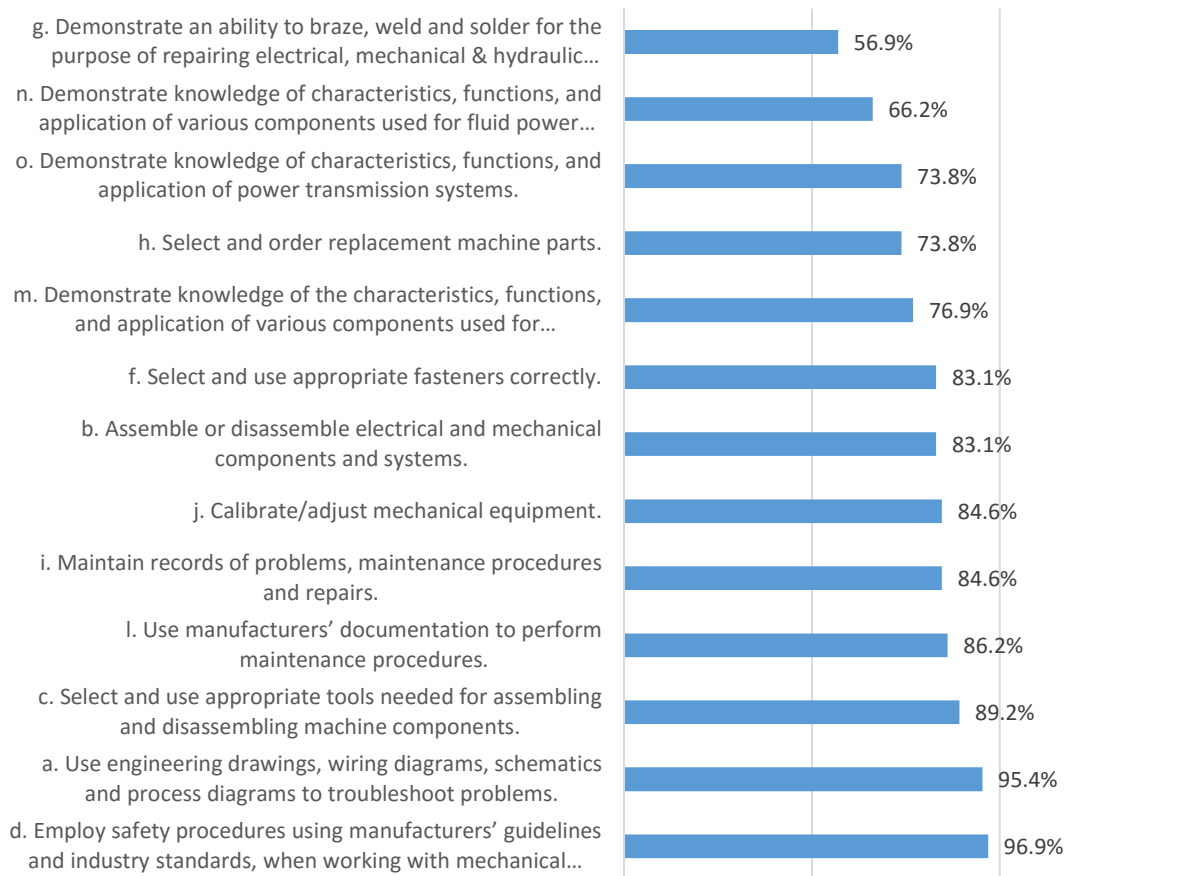


Figure 4. Maintenance and Repair of Mechanical Equipment - Competencies Considered to be Important or Very Important for Industrial Automation

### Pressing challenges

Participants were asked to list the most pressing challenges being faced by their companies. The most common theme by far—noted by over half of the respondents—was the difficulty of recruiting and retaining skilled technicians. Difficult-to-find skills included programmable logic control programming, system integration and automation, wireless technology, troubleshooting, welding, and fabrication. Some respondents also noted challenges in hiring employees who are willing to work hard, learn, and focus on customer needs.

Several respondents pointed out systemic challenges that limit the availability of skilled workers, including lack of vocational educational opportunities at the secondary school level, lack of awareness about manufacturing careers, and competition with other countries resulting in downward pressure on salaries. One respondent noted that the lack of national standards for

technicians makes it difficult for technicians to get a license or to work in another state and for employees to hire employees with the mix of skills they need.

Other challenges noted included keeping up with changing technology; demonstrating a positive attitude toward injury prevention and environmental protection; and regulatory and special interests.

### **Desired skill sets or knowledge**

Participants were asked to identify skill sets or knowledge they wish new technicians or engineers had that they don't currently have. The most commonly mentioned needs included:

- Programmable logic controller (PLC) and robot controller programming
- Soft skills, such as work ethics, customer service, effective communication, conflict resolution, time management, project management
- Troubleshooting
- Safe working practices
- Electrical knowledge - basic single and three phase electrical knowledge; higher voltage power; electric motors and drives

Also mentioned were CNC machining; mechanical, fluid power, welding and fabrication; metallurgy; 3D CAD/CAM; 3D printing; printed circuit board (PCB) design and fabrication; and RF electronics. One respondent observed that new technicians often need more formal training and new engineers often need more shop floor training.

Several respondents noted that technicians need to really understand how systems work and why—not just “throw parts at a problem” or look information up on the Internet. Having this type of knowledge is important for troubleshooting.

### **Future Directions**

Our two-year college collaborators are in the process of analyzing data from the surveys. Next steps will include:

- Continuing to collect survey responses.
- Interviewing master technicians from industry.
- Meeting as a group to discuss specific action items based on the survey results, such as curriculum changes and development of instructional materials and technologies.

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