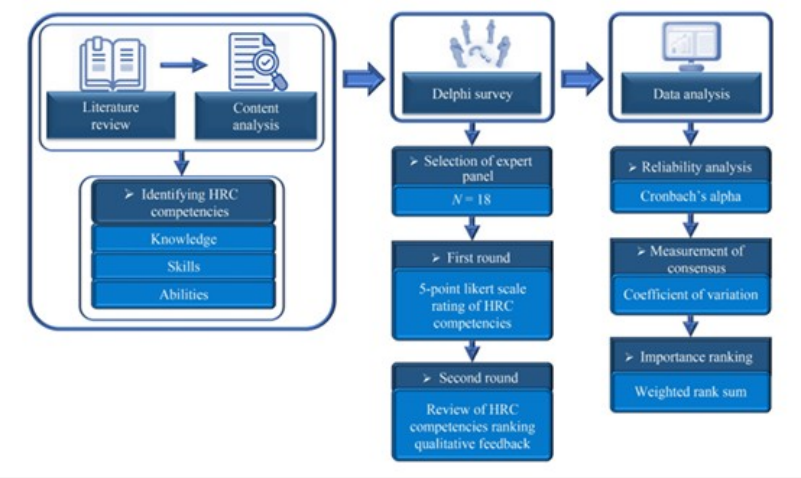
# Preparing the workforce for a robotic construction era

GA, UNITED STATES, December 26, 2025 /EINPresswire.com/ -- Robots are increasingly being deployed on construction sites to address labor shortages, reduce safety risks, and improve productivity. However, effective human–robot collaboration hinges on workers possessing the right competencies to operate, supervise, and interact with advanced robotic systems. This study identifies the most essential knowledge, skills, and abilities needed for successful collaboration in construction environments. Using a two-round Delphi survey involving experienced industry professionals, the research highlights key competency areas such as human–robot interfaces, robotic safety standards, programming, task planning, communication, safety awareness, and problem-solving. The findings provide a foundational framework that can guide workforce training, curriculum development, and the safe and efficient integration of robotic technologies in construction.



Overview of the research methodology.

The construction industry is confronting intensified labor shortages, persistent safety concerns, and long-term productivity declines, creating a pressing need for technological innovation. Robots offer significant potential by performing repetitive, hazardous, and precision-based tasks, easing the burden on human workers. Yet construction sites remain complex, unstructured, and highly variable, making full automation difficult. As a result, human–robot collaboration—combining human judgment with robotic accuracy—has become a more viable solution. Despite this potential, slow adoption persists due to limited training, workforce resistance, and unclear competency requirements. These gaps hinder large-scale implementation and reduce the benefits of robotic technologies. Due to these challenges, deeper research is needed to identify the core competencies required for effective human–robot collaboration in construction.

A research team from Virginia Tech and the University of Illinois Urbana-Champaign published a study on June 5, 2025, in Frontiers of Engineering Management, presenting the first expert-

informed competency framework for human–robot collaboration in construction. Using a structured, two-round Delphi survey, the study gathered insights from construction professionals to determine the knowledge, skills, and abilities needed for workers to collaborate effectively with robotic systems. The framework aims to support training design, workforce development, and safer, more efficient integration of robotics across construction activities.

The researchers began by conducting a comprehensive literature review and content analysis to identify potential competency elements related to robotic systems, safety protocols, human–robot interfaces, sensing technologies, and task-planning mechanisms. These preliminary competencies were organized into 20 knowledge areas, 10 skills, and 12 abilities, and then evaluated by a panel of industry experts through a two-round Delphi survey.

Experts reached consensus on several high-priority knowledge domains, including robotic anatomy and specifications, construction robot applications, sensing and perception technologies, human–robot interfaces, robotic control systems, and safety standards. Skills identified as critical included task planning, technical proficiency, programming, safety management, effective communication during human–robot interaction, and the application of data analytics and machine learning. The most important abilities emphasized safety awareness, continuous learning, problem-solving, adaptability, critical thinking, and spatial awareness—attributes essential for navigating dynamic, unpredictable construction environments.

These insights enabled the research team to develop the first unified competency framework specifically tailored to human–robot collaboration in construction. The framework highlights the need for cross-disciplinary training, workforce versatility, and alignment between education and industry expectations, offering a foundation for curriculum development, certification programs, and future competency research.

“Robots are reshaping how construction work is performed, but technology alone is insufficient,” the study’s authors explained. They emphasized that the success of human–robot collaboration depends on preparing workers who can safely supervise, communicate, and adapt alongside robotic systems. “The competencies identified in this study reflect technical, cognitive, and behavioral dimensions that are essential in real-world construction settings. Our framework provides a roadmap for educators, industry leaders, and policymakers to build a resilient, robot-ready workforce capable of meeting the demands of an evolving construction sector.”

The competency framework offers practical guidance for modernizing workforce development in construction. Educational institutions can incorporate these competency areas into engineering and construction management programs, while employers can create targeted reskilling and upskilling initiatives to strengthen safety and operational performance. Policymakers may also use the framework to establish standardized qualifications for human–robot collaboration roles. As robotics expands across surveying, inspection, prefabrication, and material handling, equipping workers with these competencies will be critical to accelerating adoption, reducing

risks, and maximizing the productivity and safety benefits of construction automation.

References

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