

How STEM powers modern agriculture

The image of farmers clad in flannel shirts while livestock pull plows through the fields may still be foremost on the minds of individuals asked to imagine farm life. But such images may no longer reflect an industry increasingly governed by advanced technology.

Even small-scale family farms have recognized the advantages of embracing technology to help make their operations more efficient and successful. Manual plows and tractors largely have been replaced by fleets of autonomous machines and precision farming technology.

Experts agree that the evolution of modern farming is a case study in the application of Science, Technology, Engineering, and Mathematics. STEM is helping to address the problem of global food security and widespread climate change. U.S. News & World Report says 27 percent of new high-skills jobs in agriculture will require a STEM education. There are many ways STEM is utilized within the agricultural sector.

- **Genomics and biotechnology:** Scientists can now identify specific traits in plant DNA that will allow for more drought-resistant crops or those better equipped to tolerate problems like downy mildew. Other traits may

make plants more capable of thriving in saline soils. Soil science also enables farmers to learn more about the complex microbiome of the soil, which ultimately can help to maximize nutrient uptake.

- **Precision agriculture:** STEM is a force behind precision agriculture, which the United States Department of Agriculture says is a term to describe farming based on observing, measuring and responding to within-field variability through crop management. Precision farming utilizes remote sensing from satellites and drones, sensors embedded in the soil or devices worn by livestock to provide real-time data. AI tools also are used to predict harvest yields and optimize fertilization and irrigation.

- **Robotics:** Automation and robotics fills a void created by human worker shortages. Agricultural engineers help design machinery or focus on the physical infrastructure of the farm. Engineers also are the minds behind innovative farming practices like vertical farming and controlled environment agriculture, which encompasses hydroponic and aeroponic systems.

- **Mathematical analysis:** Math is vital in the agricultural sector. Statistics, predictive modeling, accounting,



and risk management, are types of mathematical analysis employed to forecast global food supplies and profits.

The link between STEM and agriculture is undeniable. STEM is an important driver of the industry and only stands to gain influence in the years to come.

Follow farm safety guidelines

Agriculture is routinely ranked among the most dangerous professions around the world. Both the National Safety Council and the National Institute for Occupational Safety and Health say agriculture is one of the most hazardous industries in the United States. Farming operations continue to push forward with more mechanized and high-tech equipment that requires routine reviews of safety protocols.

According to the Bureau of Labor Statistics and NIOSH, the agricultural sector recorded a fatal injury rate of approximately 18.6 deaths per 100,000 workers in 2023. Transportation incidents, notably tractor rollovers, remain the leading cause of death. Furthermore, recent reports from the National Children's Center for Rural and Agricultural Health and Safety indicate that a child dies in an agriculture-related incident in the United States approximately every three days, which underscores the need to prioritize farm safety across all age groups.

Ensuring safe working conditions is vital within the agricultural sector. These guidelines can set the course for safer farming work.

- **Rollover Protective Structure (ROPS):** The most effective lifesaver on a farm is ROPS. When combined with seatbelt use, ROPS is 99 percent effective in preventing death during a tractor



overturn. ROPS are roll bars or roll cages fitted for wheel- and track-type tractors, says Penn State Extension. Modern guidelines indicate that all machinery should be fitted with updated guarding to prevent entanglement accidents, which are often caused by Power Take-Off shafts.

- **Respiratory protection:** Grain bins and silos can pose significant risks on a farm. This includes toxic air exposure as well as the risk for engulfment. High-profile incidents in 2023 illustrated the threat that oxygen-limiting silos can pose after deadly carbon dioxide concentra-

tions form. Risk of suffocation also is great in a grain bin if a person is engulfed by grain. Workers should never work in a bin alone and should utilize a lockout/tagout system to ensure that all augers are off before entry.

- **Chemicals and biological hazards:** High-potency pesticides and fertilizers create their own hazards on the farm. Personal protective equipment (PPE) is a must when working with chemicals. Most modern standards require proper ventilation, chemical-resistant gloves and dedicated eye protection to prevent acute

poisoning and long-term health issues.

- **Hearing protection:** Exposure to the sounds of farm machinery and other equipment can result in tinnitus (ringing in the ears) and eventual hearing loss unless hearing protection is worn regularly.

- **Fatigue and mental health:** Mental and physical fatigue of farm workers can result in injury as well. A critical trend uncovered in recent agricultural safety research ultimately led researchers to conclude that "fatigue management" needs to be prioritized, according to the United States Department of Agriculture. Tired operators can be vulnerable to lapse-of-attention errors, so farmers are encouraged to implement scheduled breaks. The Rural Health Information Hub says that stress also is a big factor for farmers. Environmental factors such as drought, floods, wildfires, pests, and diseases, as well as long hours and financial concerns, can result in feelings of isolation and frustration. Stress is a known precursor to physical accidents on the farm.

These are just some of the risk factors on farms that can lead to accident or injury. Falls from ladders, injuries from livestock, exposure to UV rays, and exposure to high levels of dust, mold and bacteria also can affect modern farmers. Agricultural safety needs to evolve as quickly as the changing operations on farms.