Cutebots in the Classroom: A Hands-On Study of Agricultural Robotics and Crop Spacing

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Introduction and Theoretical Framework

As agriculture evolves to meet global food demands, integrating technology into food production is increasingly vital (Khan et al., 2021). Tools like robots, sensors, and drones enhance efficiency, productivity, and sustainability (Pedro, 2017). However, a gap remains between technological advancements and the skills of the future workforce, especially at the middle school level (Borda et al., 2023; Rivera-Ferre, 2008). Students often lack the hands-on experience needed to effectively use these tools (Bampasidou et al., 2024; Becerra-Encinales et al., 2024).

To address this, we applied active engagement and reflection, which aligned with constructivist learning theory (Piaget, 1970; Vygotsky, 1978), and Kolb's (1984) experiential learning cycle. Authentic learning experiences- in agricultural education are aligned with experiential and constructivist learning theories (Knobloch, 2003). This study provided middle school students with a learner-centered activity comparing manual and robotic planting using Smart Cutebots. These robots simulated row detection and crop spacing, helping bridge the gap between theory and practice through inquiry-based learning.

Connection to Literature

Kolb's (1984) experiential learning theory supports the idea that students learn more effectively through hands-on experience, reflection, and application. The Smart Cutebot activity aligns with this by offering middle school students' practical exposure to agricultural practices. Gollakota and Srinivas (2011) emphasized that agricultural robotics improve precision and efficiency—skills essential for the agricultural STEM workforce. Integrating STEM into agricultural education to makes learning more relevant (Wang & Knobloch, 2020). Similarly, early exposure to precision agriculture tools builds essential technical skills (Mohyuddin et al., 2024). Constructivist approaches (Saleem et al., 2021) further support this learner-centered, collaborative design for this lesson.

Purpose and Objectives

The purpose of this innovative teaching activity was to enhance middle school students' understanding of agricultural robotics and their application in crop farming. The specific objectives were to: (1) demonstrate the limitations of manual crop spacing methods in agriculture; engage students in using robotic tools (Smart Cutebot) to simulate the benefits of precision farming; and, (2) develop critical thinking and observational skills through hands-on activities and guided reflection.

Method

This lesson was taught in an agricultural science class at a public middle school located in Lafayette, Indiana. The lesson followed a two-part, group-based structure.

First Activity – Hands-On Planting Activity to Explore Manual Planting Techniques and Challenges

Students *(N = 16*) were divided into four groups. Each group was given cardboard (representing farmland), playdough (to simulate soil), bean seeds, and measuring tools. They were tasked with planting 15 seeds using their own spacing strategy. After planting, they used rulers to measure the distances between seeds and reflected on the consistency and alignment of their rows. Students recorded their observations on the challenges faced when planting manually.

Second Activity – Robotic Simulation Activity to Compare Manual and Automated Planting Methods

Students assembled and programmed a Smart Cutebot using a line-following algorithm. A paper with black lines representing cornfield rows. The Smart Cutebots followed the black lines, simulating row detection and crop spacing analysis. Students then compared their observations between manual methods and robotic simulation using a guided activity notes handout. They discussed the accuracy, labor, time, and energy requirements for each method.

Results

The hands-on activities revealed clear contrasts between manual and robotic planting methods. During the manual planting phase, students consistently noted challenges (quotes are listed below) such as time consumption, inconsistent spacing, and labor intensity. Groups 1 and 2 remarked that "manual farming practices are time-consuming and lead to inconsistent spacing," while Groups 3 and 4 observed that it "requires more labor and leads to uneven rows."

In contrast, the robotics integration phase sparked enthusiasm and deeper engagement. Students highlighted the benefits of using Smart Cutebots, noting that "robots save time, energy, and increase accuracy" (Group 1), and "technology can make farming faster and less labor-intensive" (Group 2). Groups 3 and 4 emphasized how robotics "improve farming efficiency" and "can save money."

Overall, students were given a posttest, and they agreed they were motivated, and the robotics activities encouraged critical thinking. They made real-world connections, recognizing how automation could reduce labor costs and enhance agricultural productivity. These findings align with prior research (Eguchi, 2016; Ottenbreit-Leftwich et al., 2024) on the value of educational robotics in fostering STEM skills and interdisciplinary learning.

Future plans/advice to others

This activity demonstrated the value of experiential learning in STEM-focused Agricultural Food and Natural Resources (AFNR) education, especially when integrating robotics to teach concepts like automation, crop spacing, and precision farming. Based on classroom observations, we recommend that educators give students 20 minutes for programming and troubleshooting. Some students struggled with coding the Smart Cutebots, and students were less engaged in the activity. Students should be provided pre-built code templates or a short tutorial beforehand they start coding. Also, educators should model a sample coding sequence, provide clear instructions, and assign role assignments. Group dynamics varied, and some students were unsure of their tasks. Assigning roles to each member such coder, observer, and recorder would help improve collaboration and engagement. The use larger or more durable materials is recommended because the cardboard and playdough setup was effective but fragile. Laminated planting boards or reusable kits could improve consistency and reduce setup time. This learner-centered activity (Knobloch, 2003) can be a powerful tool for introducing precision agriculture in middle school classrooms. With minor adjustments, it can better support student engagement, collaboration, and skill development for future careers in agricultural technology.

Costs/Resources Needed

Implementing this activity requires a modest investment in both materials and preparation time. Each Smart Cutebot costs approximately \$50–\$70, depending on the vendor and accessories included. Additional classroom materials such as cardboard, beans, playdough, and rulers are inexpensive and readily available. Access to laptops or tablets is essential for programming the robots. Ideally, each group of 3–4 students should have one device to ensure active participation.

Instructor preparation is also key. Teachers should allocate time for training in basic robotics and STEM integration curriculum development, which may include watching tutorials, testing the Cutebots, and preparing troubleshooting guides. A minimum of 2–3 hours of prep time is recommended before delivering the lesson.

The classroom activity itself takes about 90–120 minutes, split between manual planting and robotic simulation. Educators should also plan for 15–20 minutes of reflection and discussion to reinforce learning outcomes.

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