

**Evaluating Drone Technology Training Effectiveness for Louisiana 4-H Extension Agents:  
A Pre-Post Assessment Study**

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## **Introduction & Literature review**

The U.S. agricultural drone market reached \$1.35 billion in 2022 and is projected to expand at a compound annual growth rate of 25.0%, reaching \$5.89 billion by 2030 (Grand View Research, 2023). This explosive growth reflects the transformative potential of drone technology in modern agriculture. Drones are revolutionizing precision agriculture by enhancing efficiency, accuracy, and sustainability in farm management. They enable high-resolution crop monitoring through multispectral and hyperspectral imaging, allowing for early detection of plant stress, diseases, and pest infestations, which leads to timely interventions and increased yields (Guebsi et al., 2024; Naji, 2019; Ram et al., 2024). Their ability to provide real-time data on crop health, soil moisture, and nutrient levels optimizes irrigation, fertilization, and pesticide application, reducing input costs and environmental impact (Getahun et al., 2024; Mamabolo et al., 2025; Rejeb et al., 2022). AI-driven drone analytics further enhance decision-making by automating data analysis for site-specific crop management while reducing labor costs.

Despite these advantages, significant knowledge gaps persist among agricultural extension professionals. De Koff's (2017) study highlights the lack of structured Unmanned Aircraft System (UAS) training for adults and youth, despite the growing demand for drone technology in agriculture and STEM education. Additionally, limited research on farmer familiarity with drones, absence of standardized curricula, and lack of FAA-certified educators create barriers to adoption. These challenges emphasize the need for targeted training, policy alignment, and structured programs to effectively integrate drones into extension education and prepare professionals with essential drone operation skills and regulatory knowledge.

### **Purpose and research objectives**

The primary purpose of this study is to assess the effectiveness of a structured drone workshop in improving Louisiana 4-H extension agents' technical knowledge, regulatory understanding, and operational confidence, while identifying key factors that contribute to successful learning outcomes in integrating drone technology in non-formal education programs.

#### **Research Objectives**

1. To determine 4-H extension agents' competency levels in drone operations and maintenance, knowledge of drone regulations and safety protocols, and confidence levels regarding drone operations before the workshop training in Louisiana.
2. To determine 4-H extension agents' competency levels in drone operations and maintenance, knowledge of drone regulations and safety protocols, and confidence levels regarding drone operations after the workshop training in Louisiana.
3. To compare 4-H extension agents' competency levels in drone operations and maintenance, knowledge of drone regulations and safety protocols, and confidence levels regarding drone operations before and after the workshop training in Louisiana.

4. To examine 4-H extension agents' perceptions of training effectiveness and knowledge transfer to identify areas for program improvement following the drone training workshop in Louisiana.

## **Conceptual Framework**

This study is grounded in two complementary theoretical frameworks: Kolb's Experiential Learning Theory (1984) and Bandura's Self-Efficacy Theory (1977). Kolb's model conceptualizes learning as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation. These stages are evident in the training activities, which included hands-on drone operation, reflection, and integration of regulatory knowledge.

Complementing this, Bandura's Self-Efficacy Theory explains how confidence develops through four main sources: mastery experiences, vicarious learning, social persuasion, and emotional states. These were integrated into the training design through practice opportunities, peer observation, supportive instruction, and a safe learning environment.

## **Methods**

This study employed a one group pre-test -post-test design to evaluate the impact of drone training workshops on Extension Agents' operational knowledge and confidence in drone operation. The program was implemented across four Louisiana regions: Central, West, Southwest or Northeast, & Northwest ensuring diverse participant representation of and comprehensive regional coverage. Participants comprised of 56 Louisiana 4-H Extension Agents selected based on their involvement in Extension programming and interest in integrating drone technology into their agricultural outreach work.

The implementation process followed a structured organizational approach: the 4-H STEM coordinator contacted regional directors to arrange workshops, secured approval from regional coordinators, and then coordinated with extension personnel to finalize workshop logistics. The training workshops regimen included: (1) Comprehensive instruction on drone regulations and legal requirements (2) Preparation for and completion of the Trust exam. (3) Hands-on flight training with Co-drone Edu & Exo-mini drones. (4) Practical experience with drone cage assembly to replicate youth-focused drone activities and competitions.

Upon completion, participants evaluated their training experience through a standardized assessment form. The evaluation instrument consisted of both quantitative and qualitative measures. The quantitative component included three constructs measured on a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree), assessing participants' pre- and post-workshop: (1) drone operation and maintenance competency, (2) understanding of regulations and safety protocols, and (3) confidence in drone operation capabilities. The qualitative component consisted of four open-ended questions examining participants' perceptions of learning outcomes, training effectiveness, and suggestions for program improvement. Internal consistency reliability was determined using Cronbach's alpha, which yielded  $\alpha = 0.789$ , indicating acceptable reliability and content validity established through expert review and alignment with workshop learning objectives.

Quantitative data were analyzed using SPSS software. Paired-samples t-tests were conducted to evaluate changes in participants' knowledge and confidence from pre- to post-workshop across each of the three constructs. Effect sizes were calculated using Cohen's d to assess practical significance, with an alpha level of .05 used for all statistical tests. Qualitative data from the open-ended questions were analyzed following Saldaña's (2021) coding procedures. Responses were reviewed for familiarity, and first cycle coding employed both descriptive coding to summarize the primary topic of each response and In Vivo coding to preserve participants' own language and expressions. Second cycle pattern coding was then used to organize initial codes into broader categories and themes representing participants' perceptions of learning outcomes and program effectiveness.

## Results

### Participant Completion

Of the 56 extension agents enrolled in the drone training workshop, all completed both pre-workshop and post-workshop assessments (100% completion rate).

### Objective 1: Pre-Workshop Competency Levels

Table 1 presents descriptive statistics for all three competency domains at baseline. Prior to the workshop, extension agents reported low competency levels across all measured domains. Drone operational knowledge showed a mean score of 1.89 (SD = 1.00) on a 5-point scale, indicating limited baseline understanding of drone operations and maintenance procedures. Regulatory knowledge demonstrated the lowest baseline competency (M = 1.71, SD = 1.04), suggesting minimal familiarity with FAA regulations and safety protocols. Drone flying confidence was similarly low (M = 2.02, SD = 1.17), reflecting agents' limited self-efficacy in operating drones prior to training.

**Table 1**

*Pre-Workshop Competency Levels (N = 56)*

Competency Domain	M	SD	Range
Drone Operational Knowledge	1.89	1.00	1.0–5.0
Regulatory Knowledge	1.71	1.04	1.0–5.0
Drone Flying Confidence	2.02	1.17	1.0–5.0

*Note.* All competencies measured on a 5-point scale where 1 = *strongly disagree* and 5 = *strongly agree*.

### Objective 2: Post-Workshop Competency Levels

Table 2 presents descriptive statistics for all three competency domains following the workshop. After completing the training, extension agents reported substantially higher competency levels across all measured domains. Drone operational knowledge increased to a mean of 4.21 (SD = 0.49), indicating participants developed strong understanding of drone

operations and maintenance procedures. Regulatory knowledge showed the highest post-workshop mean ( $M = 4.27$ ,  $SD = 0.56$ ), suggesting participants gained comprehensive knowledge of FAA regulations and safety protocols. Drone flying confidence reached 4.05 ( $SD = 0.52$ ), reflecting increased self-efficacy in operating drones.

**Table 2**

*Post-Workshop Competency Levels (N = 56)*

Competency Domain	M	SD	Range
Drone Operational Knowledge	4.21	0.49	3.0–5.0
Regulatory Knowledge	4.27	0.56	3.0–5.0
Drone Flying Confidence	4.05	0.52	3.0–5.0

*Note.* All competencies measured on a 5-point scale where 1 = *strongly disagree* and 5 = *strongly agree*

### **Objective 3: Comparison of Pre-Workshop and Post-Workshop Competency Levels**

#### Drone Operational Knowledge

Participants reported significantly higher agreement regarding their drone operational knowledge after the workshop ( $M = 4.21$ ,  $SD = 0.49$ ) compared to before the workshop ( $M = 1.89$ ,  $SD = 1.00$ ),  $t(55) = -18.55$ ,  $p < .001$ ,  $d = 2.48$ , 95% CI [2.07, 2.57]. This represented a large effect, indicating that the workshop substantially enhanced participants' self-reported understanding of drone operations and maintenance procedures. The mean increase of 2.32 points on the 5-point Likert scale reflects a shift from disagreement about possessing operational knowledge at baseline to strong agreement following training.

#### Regulatory Knowledge

Similarly, participants' agreement regarding their regulatory knowledge increased significantly from pre-workshop ( $M = 1.71$ ,  $SD = 1.04$ ) to post-workshop ( $M = 4.27$ ,  $SD = 0.56$ ),  $t(55) = -17.74$ ,  $p < .001$ ,  $d = 2.37$ , 95% CI [2.27, 2.84]. This large effect demonstrated that participants substantially increased their self-reported understanding of FAA drone regulations and safety protocols. The mean improvement of 2.55 points represented the largest absolute gain among the three competency domains, suggesting that regulatory content was particularly effective in addressing agents' baseline knowledge gaps.

#### Drone Flying Confidence

Participants' self-reported drone flying confidence increased significantly from pre-workshop ( $M = 2.02$ ,  $SD = 1.17$ ) to post-workshop ( $M = 4.05$ ,  $SD = 0.52$ ),  $t(55) = -14.59$ ,  $p < .001$ ,  $d = 1.95$ , 95% CI [1.76, 2.32]. This large effect indicated substantial gains in participants' agreement that they possessed confidence in their ability to operate drones safely and effectively.

The mean increase of 2.04 points reflected a shift from disagreement about having confidence at baseline to strong agreement following training.

**Table 3**

*Paired-Samples t-Test Results Comparing Pre- and Post-Workshop Competency Levels (N = 56)*

Competency Domain	Mean Difference	95% CI	t	df	p	Cohen's d
Drone Operational Knowledge	2.32	[2.07, 2.57]	-18.55	55	< .001	2.48
Regulatory Knowledge	2.55	[2.27, 2.84]	-17.74	55	< .001	2.37
Drone Flying Confidence	2.04	[1.76, 2.32]	-14.59	55	< .001	1.95

*Note.* All mean differences represent post-workshop minus pre-workshop scores. Negative t-values indicate higher post-workshop scores. Cohen's d effect sizes: small = 0.20, medium = 0.50, large = 0.80 (Cohen, 1988).

#### **Objective 4**

##### **Theme #1: Hands-on learning experience that exceeded expectations.**

In this theme we analyzed participants responses on what stood out to them and their responses showed that they were consistently expressing surprise at how easy drone technology was to grasp when experienced through practical application and instruction. Many noted the unexpected ease of flying, with one participant stating, "Flying it was more simple than I made it out to be on my mind." Similarly, the coding component surpassed expectations, as one participant mentioned, "I've always thought coding would be too scientific, but it was actually quite easy."

Furthermore, participants reported significant learning gains, with many noting they had little to no prior drone knowledge before the training. Key areas of new knowledge included coding techniques, flight operations, and regulatory requirements. Participants were particularly surprised by the depth of regulations, with one noting that "Part 107 is more in-depth than I previously thought."

The effective instruction was another integral aspect that formed participants' positive experience, with many praising the instructor's scaffolded approach and thoroughness. One participant noted, "The instructor did a nice job helping us understand the ways to move the drone prior to letting us go on our own. I appreciate the scaffolded approach for learning the rules, how-to, coding, and the relay activities." This combination of hands-on learning and skillful instruction created an engaging environment that transformed participants' preconceptions about drone technology complexity.

##### **Theme #2: Training effectiveness perceptions and areas for program improvement.**

All participants who provided feedback indicated that the training was effective in helping them gain knowledge, competency, and confidence in drone technology, demonstrating unanimous satisfaction with the program outcomes. However, some participants suggested several improvements to enhance future workshops, including additional flight time, more challenging flight activities such as obstacle courses, post-training access to materials, and adjusting the instructional pace. While most feedback was positive, a small number of participants (n=2) recommended slowing the pace of instruction.

### **Conclusion, Limitations, Implications, Recommendations.**

Based on the quantitative and qualitative data, we concluded that the drone training workshop was highly effective. Three interrelated mechanisms emerged as key contributors to this success: hands-on learning that reduced perceived complexity, scaffolded instruction that built confidence incrementally, and expert facilitation that integrated theoretical and practical knowledge effectively.

Hands-on learning systematically reduced participants' perceived complexity of drone technology. This finding aligns with technology adoption research demonstrating that perceived complexity creates the primary barrier to adoption (Lee et al., 2024; Masi et al., 2022). The workshop addressed this perception-reality gap by providing direct evidence through successful flight operations. This active learning approach reflects reform-based professional development models that Smith et al. (2017) found to be more effective than traditional lecture-based approaches in 4-H contexts, though their research revealed such reform-based methods incorporating active learning remain underutilized in state 4-H programs. Therefore, we recommend extension programs introducing emerging technologies which allocate adequate time for hands-on practice rather than relying solely on demonstrations or lectures, as theoretical knowledge increases awareness without addressing perceptual barriers preventing adoption.

Scaffolded instruction-built confidence through progressive mastery experiences. The workshop's progression from regulatory instruction to knowledge testing to application of basic controls and precision maneuvers created multiple success opportunities before advancing complexity. Research on technology self-efficacy confirms that mastery experiences from professional development provide the most influential source of confidence for educators (Barton & Dexter, 2020; Clark, 2022). This incremental approach built confidence necessary not only for personal technology use but also for teaching drones to youth audiences. We recommend extension professional development should include scaffolded approaches with structured progression and explicit checkpoints, as confidence development requires dedicated time and intentional design beyond simple equipment access.

Expert facilitation integrated theoretical and practical knowledge led to effective instruction. The facilitator's ability to explain why regulatory requirements existed not just what they required created more meaningful learning than rote memorization. While Smith et al. (2017) found that most 4-H professional development is expert-led, they noted that reform-based models emphasize pedagogical skill alongside content expertise, fostering learner-centeredness rather than hierarchical knowledge transmission. We recommend extension organizations should recognize that facilitator expertise in both content and instructional methods is essential and should invest in facilitators with such expertise.

Future research should examine: (1) knowledge retention at 3-, 6-, and 12-month intervals to assess whether booster sessions are needed, (2) actual integration of drones into 4-H programming and barriers agents encounter, (3) optimal training formats and practice time durations, and (4) youth learning outcomes when agents integrate drones into programs.

Study limitations include self-reported data, single post-test measurement without follow-up, insufficient flight time for advanced activities and lack of post-training resource materials.

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