Research

Brief Instruction, Deep Reflection: STEM Undergraduates' Perspectives on Precision Agriculture

Chin-Ling Lee
University of Georgia
Department of Agricultural Leadership, Education, and Communication
405 College Station Road,
Athens, GA 30602
cllee@uga.edu

Maria Reynalyn Helm
University of Georgia
Department of Agricultural Leadership, Education, and Communication
405 College Station Road,
Athens, GA 30602
Maria.Helm@uga.edu

Brief Instruction, Deep Reflection: STEM Undergraduates' Perspectives on Precision Agriculture

Introduction/Need for Research

The widespread adoption of precision agriculture applications has transformed the labor requirements and productivity performance in agricultural production (Koutsos & Menexes, 2019). One challenge in adopting precision agriculture is the shortage of technical expertise (Erickson et al., 2018; Mansoor et al., 2025). In recent years, enrollment in agriculture-related courses has continued to decline, while enrollment in STEM fields has increased (Tran et al., 2021). This trend creates a critical gap in the agricultural workforce, as the growing demand for skilled professionals in precision agriculture remains unmet (Oluwoye & Debnath, 2022; Zaremohzzabieh et al., 2021). Therefore, understanding whether knowledge gained through intervention-based learning in precision agriculture can foster STEM undergraduates' interest in agricultural technology fields will positively impact future talent cultivation for precision agriculture-related employment.

The following research questions guided this study: (a) How do STEM undergraduates make sense of precision agriculture following a brief instructional introduction and reflective dialogue? (b) What personal values, motivations, or prior experiences influence their openness or hesitation toward the field? (c) How do they relate precision agriculture to their developing academic and professional identities?

Theoretical Framework

Interpretive Description (Thorne, 2016) is a qualitative approach suited for generating practice-oriented insights into how learners construct meaning, particularly within education research (Burdine et al., 2021). This framework aligns with our aim of examining how early-career STEM undergraduates made sense of precision agriculture following a brief instructional intervention (Creswell & Poth, 2018; Thorne, 2025). Rogers' (2003) Diffusion of Innovations framework provided the analytic scaffolding for interpreting students' perceptions of agricultural technologies and their relevance to science-based disciplines. In this study, the researchers developed a short video introducing the five innovation attributes of precision agriculture, including relative advantages, compatibility, complexity, trialability, and observability.

Methodology

This qualitative study used an asynchronous online discussion board to engage participants to share reflections on the intervention. Participants were selected through purposive, criterion, and maximum-variation sampling (Creswell & Poth, 2018; Patton, 2015). The sample included 112 first- and second-year STEM majors enrolled in foundational science courses, representing a group with emerging disciplinary knowledge but limited prior exposure to agriculture. Data sources consisted of open-ended written reflections ($n = 75$) and week-long asynchronous discussions ($n = 64$). Data were analyzed using the Hermeneutic Abductive Method of Interpretive Description (HAM-ID), an approach developed in this study to integrate the Hermeneutic Circle of Reflexivity and Analysis (Helm et al., 2025) with Thorne's (2025) interpretive design.

Results

Conceptualization of Precision Agriculture

Students demonstrated cognitive reconstruction, linking unfamiliar agricultural practices to familiar scientific ideas. They characterized precision agriculture as an evidence-based, technologically supported system that translated theoretical science into practical application. One student noted that the tools made it feel "like seeing the textbook come to life," while another explained that sensors allow farmers to "see differences instantly" across plants.

Values, Motivations, and Experiences Influencing Openness

Engagement was shaped by personal ethics, curiosity, and prior exposure. Students viewed precision agriculture as environmentally responsible, noting it "reduces waste and pollution," while others emphasized that innovation should "help farmers, not replace them."

Perceived Opportunities and Challenges

As students shifted from conceptual understanding to applied reasoning, they identified precision agriculture as inherently interdisciplinary, integrating biology, environmental science, and technology. They also acknowledged structural barriers, questioning whether "small farms can afford it" or whether technological reliance might "replace farmers' knowledge."

Interpretive Synthesis

The HAM-ID process revealed a developmental pattern of *surprise, integration, and reflection.* Students' understandings evolved from viewing agriculture as peripheral to science toward recognizing it as a dynamic, research-based, and socially responsive field. Precision agriculture thus functioned not merely as content but as *context for identity formation*, a means through which students articulated how knowledge, innovation, and responsibility intersect in shaping sustainable futures.

Implications/Recommendations/Impact on Profession

The findings revealed how intervention-based learning grounded in the Diffusion of innovation framework can engage STEM undergraduates in precision agriculture and foster interdisciplinary identity. Students' cognitive evolution toward precision agriculture involves restructuring unfamiliar agricultural practices through familiar scientific principles, highlighting the need to introduce agricultural innovation within students' existing disciplinary frameworks. Within this context, precision agriculture becomes not merely instructional content, but a transformative domain that helps students articulate connections among technological innovation, ethical responsibility, and sustainable futures. Educators and curriculum designers should emphasize the relative advantage of precision agriculture for efficiency and sustainability, ensuring compatibility with students' STEM foundations. We recommend integrating short, targeted multimedia interventions, such as brief instructional videos, paired with guided reflections to deepen conceptual understanding and professional resonance. This approach also benefits the cultivation of skilled professionals for the precision agriculture workforce.

References

Burdine, T., Thorne, S., & Sandhu, G. (2021). Interpretive description: A flexible qualitative methodology for medical education research. *Medical Education*, *55*(3), 336–343. https://doi.org/10.1111/medu.14380

Creswell, J.W., & Poth, C.N. (2018). *Qualitative inquiry & research design: Choosing among five approaches,* 5th ed. SAGE.

Erickson, B., Fausti, S., Clay, D., & Clay, S. (2018). Knowledge, skills, and abilities in the precision agriculture workforce: An industry survey. *Natural Sciences Education, 47*(1), 1-11. https://doi.org/10.4195/nse2018.04.0010

Helm, M. R., Fuhrman, N. E., Peake, J. B., Irwin, K. M., & Rubenstein, E. D. (2025). A Qualitative study of factors influencing teaching self-efficacy of elementary agricultural education teachers. *Journal of Agricultural Education*, *66*(2), Article 11. https://doi.org/10.5032/jae.v66i2.2779

Koutsos, T., & Menexes, G. (2019). Economic, agronomic, and environmental benefits from the adoption of precision agriculture technologies: A systematic review. *International Journal of Agricultural and Environmental Information Systems*, *10*(1), 40–56. https://doi.org/10.4018/IJAEIS.2019010103

Mansoor, S., Iqbal, S., Popescu, S. M., Kim, S. L., Chung, Y. S., & Baek, J.-H. (2025). Integration of smart sensors and IOT in precision agriculture: trends, challenges and future prospectives. *Frontiers in Plant Science, 16*, 1587869. https://doi.org/10.3389/fpls.2025.1587869

Oluwoye, J., & Debnath, R. (2022). Assessment and analysis of undergraduate fall enrollment trends of the selected College of Agriculture at the 1890 land-grant universities: 1996 to 2018. *International Journal of Scientific Advances*, *3*(5), 750–753. https://doi.org/10.51542/ijscia.v3i5.12

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). SAGE. https://us.sagepub.com/en-us/nam/qualitative-research-evaluation-methods/book232962

Rogers, E. M. (2003). *Diffusion of innovations*, fifth ed. California: Free Press.

Thorne, S. (2025). *Interpretive description: Qualitative research for applied* practice, 3rd ed. Routledge. https://doi.org/10.4324/9781003503538

Tran, Q. N., Meyerink, M., Aylward, A., & Luo, F. (2021). College enrollment and STEM major choice in a rural State: A statewide Examination of recent high school cohorts. *Theory & Practice in Rural Education*, *11*(1), 40–59. https://doi.org/10.3776/tpre.2021.v11n1p40-59

Zaremohzzabieh, Z., Krauss, S. E., D'Silva, J. L., Tiraieyari, N., Ismail, I. A., & Dahalan, D. (2021). Towards agriculture as career: Predicting students' participation in the agricultural sector using an extended model of the theory of planned behavior. *The Journal of Agricultural Education and Extension*, *28*(1), 67–92. https://doi.org/10.1080/1389224X.2021.1910523