STEM Undergraduate Students' Critical Reflections on Precision Agriculture through Video-based Intervention

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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 Science, Technology, Education, and Mathematics (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 experience and 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

This study is guided by Self-Determination Theory (Deci & Ryan, 1985), which posits that engagement and the internalization of learning are driven by the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. Precision agriculture is examined as a learning context that supports these needs. This framework guided the analysis of how precision agriculture practices shape STEM students' learning motivation, open-mindedness, and evolving perceptions of precision agriculture. In this study, the researchers developed a short video introducing the Rogers' (2003) five innovation attributes of precision agriculture, including relative advantages, compatibility, complexity, trialability, and observability.

Methodology

This qualitative study was grounded in a constructivist paradigm and 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 and Conclusions

Autonomy-Oriented 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.

Competence-Oriented 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."

Relatedness-Oriented 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 that a brief, strategically designed video that both met the requirements of self-determination theory and highlighted the attributes of innovation diffusion can effectively shift STEM students' career aspirations toward precision agriculture. The video established competency awareness by visualizing precision agriculture's comparative advantages and alignment with STEM skills. The findings also confirmed that when providing supports autonomy by emphasizing testability and observability (e.g., real-time data) to enable self-directed exploration. Relevance and value alignment are reinforced by highlighting low-complexity pathways and showcasing career prospects that promote sustainability and farming efficiency. 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.

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