Advanced Training in Precision Farming: The Italian On-Farm Pilot Experimentation of the BOOST Project

Matteo Belletti[1*], Giacomo Staffolani[1], Giulia Chiaraluce[1], Deborah Bentivoglio[1], Adele Finco[1]

Abstract

This paper presents the first Italian case study of a participatory training course in agribusiness and precision farming, implemented on-farm with the BOOST Project method. The study adopts Yin's case study methodology to investigate this innovative approach, focusing on peer-to-peer learning and mentorship as systemic solutions to the persistent training gap in farm technological management. Results, which are preliminary and longitudinal in nature, suggest that project-based education may significantly enhance effective technology adoption in agriculture.

Key words: *Agribusiness, Precision Farming, Case Study Methodology, Participatory Training, Technology Adoption.*

Introduction

The digital transformation of the agri-food sector is rapidly reshaping the skills required by farmers, technicians, and agribusiness entrepreneurs, especially in relation to the uptake of precision agriculture (PA) tools (Wolfert et al., 2017; Zarco-Tejada, Hubbard and Loudjani, 2014). Precision agriculture (PA)—with its integration of digital tools, data-driven decision-making, and site-specific management—promises to increase productivity, sustainability, and competitiveness. In Italy and across much of Europe, however, technology adoption remains limited not due to lack of information—commercial offerings are abundant—but rather by a significant shortage of high-quality, project-based training that enables real-world application and strategic use of precision farming solutions (Klerkx et al., 2019).

Agricultural systems today face three key interacting forces:

- *Global economic changes* drive ever-increasing concentration in the agri-food markets (World Bank, 2024; Alexandratos and Bruinsma, 2012).
- *Generational change* introduces new skills and management styles, but it also presents challenges in knowledge transfer.
- *Climate change* increases uncertainty and demands resilient, adaptive responses (OECD, 2025).

These interacting forces necessitate adaptive, systemic approaches to agricultural innovation and education that can respond flexibly to economic, social, and environmental dynamics (Figure 1).

[1] Department of Agricultural, Food, and Environmental Sciences, Università Politecnica delle Marche, Via Brecce Bianche, 60131, Ancona, Italy, Emails: m.belletti@univpm.it, g.staffolani@staff.univpm.it, g.chiaraluce@pm.univpm.it, d.bentivoglio@univpm.it, a.finco@staff.univpm.it

[*] Corresponding author

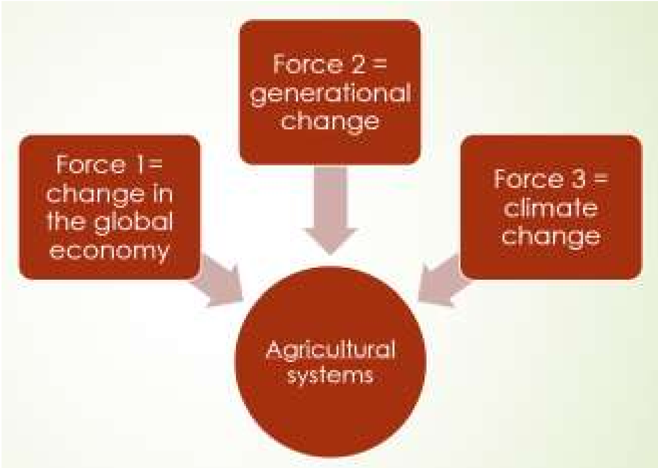

Figure 1 - Agricultural systems under the pressure of 3 main forces

Within this context, the European "BOOST" Erasmus+ project provides the framework for Italy's first pilot training based on mentorship and participatory learning, targeting farm entrepreneurs, agronomists, and students, and focused on technological farm management.

This study draws on the "Shifting the Burden" systems thinking archetype (Kim, 1992; Senge, 1990). While typical "quick-fix" trainings offer only short-term relief, the BOOST approach—mentorship and participatory learning embedded in farm management—is conceptualized as a virtuous, long-term systemic solution for building enduring capabilities and making leading farms into "living academies" that drive resilience and systemic transformation in agriculture.

The training experiment was co-designed and delivered by Agricolt Brandoni[1]—a leading Italian farm—and the Università Politecnica delle Marche (Univpm), grounded in participatory, learning-by-doing principles (Kolb, 1984). Experiential learning within real farm contexts has been shown to effectively enhance adoption of sustainable practices among practitioners (Gerster Bentaya et al., 2024).

The article applies Yin's (2018) case study methodology to systematically analyze the design, implementation, and outcomes of the BOOST pilot VET (Vocational Education and Training) in Italy. This approach suits investigations of contemporary, real-life phenomena using direct observation, participant feedback, and project documentation to achieve analytical depth and methodological rigor.

The pilot training transformed the partner farm (Agricolt) into an "open-air classroom," applying theoretical learning through practical tasks and collaborative problem-solving. This dynamic fostered both technical and entrepreneurial competencies. The mentor-trainee relationship was deliberately non-hierarchical and peer-oriented, creating a collaborative space in which several trainees themselves were advanced agripreneurs, further strengthening the climate of exchange.

A key feature of the BOOST experience is its focus on mentorship and peer-to-peer learning. Mentorship sessions, guided by the Agricolt Brandoni management team and the Univpm research team, enabled participants to confront challenges, craft solutions,

[1] Agricolt Brandoni's website: https://agricoltbrandoni.it/

and refine business models for technological farm management.

This approach not only strengthens technical skills but also cultivates entrepreneurial spirit and collaborative innovation, which are crucial factors for the effective scaling and diffusion of digital agriculture (Carolan, 2016). The pilot training design also aligns with the principles of the Five-Component Future Competence (5CFC) model, which integrates knowledge, skills, attitudes, values, and real-life experience in agricultural education (Mulder, 2017).

To guarantee rigor, the study uses triangulation across multiple data sources (surveys, observation, feedback), enabling fuller documentation and interpretation of outcomes (Flick, 2018; Carter et al., 2014; Denzin, 2009).

Our analysis particularly focuses on i) the formative process, ii) participant roles, and iii) peer learning mechanisms underpinning the BOOST pilot VET, with the aim of informing the creation of scalable, field-ready education models that respond to the real needs of the agri-food sector in the digital era. Beyond simply detailing the pilot training, the study seeks to offer practical recommendations and curriculum guidance for expanding innovation and effective digital adoption across the European agricultural context.

Methodology

This study adopts Robert K. Yin's (2018) case study methodology, which is particularly suited for investigating complex, contemporary phenomena within their real-life context through multiple sources of evidence. As anticipated in the introduction, the research is exploratory and inductive, aiming to develop theoretical propositions on designing effective VET pathways in farm technological management—specifically, agribusiness and precision agriculture – rather than testing predefined hypotheses or measuring definitive outcomes. The Italian BOOST pilot represents a single embedded case, allowing an in-depth exploration of the design, implementation, and evolving outcomes of an innovative on-farm vocational training model.

The research is structured around five core components:

Case study question: How can a participatory, on-farm vocational training model enhance learning effectiveness, foster innovation adoption, and stimulate entrepreneurial awareness in agribusiness and precision agriculture?

Propositions: an applied, peer-based training approach, grounded in real farm conditions and emphasizing mentorship, produces more meaningful and applicable learning outcomes than traditional, top-down educational methods (Scharmer, 2016).

Unit of analysis: the unit of analysis is the Italian experimental vocational training pathway in farm technological management, which has been characterized by mentorship and participatory learning. This pilot program has been placed at the Agricolt Brandoni farm and implemented collaboratively by the Agricolt Brandoni management team and the Univpm within the BOOST project framework.

Logic linking data to propositions: it involves data collection that combines both quantitative and qualitative methods, including structured pre- and post-training surveys that assess learners' perceptions and knowledge acquisition. Triangulation employs multiple data sources to cross-validate findings and enhance credibility, richly documenting the formative process, participant engagement, and evolving results of the training pathway, rather than measuring outcomes. By integrating multiple sources of evidence, the study ensures a robust and nuanced description of how the VET pathway is experienced and constructed in practice, supporting critical analysis of its pedagogical architecture and implementation. Data is used both to document the formative process, capturing initial participant reactions, and to provide a final evaluation as stated by trainees.

Criteria for interpreting findings: key indicators encompass enhanced learner confidence, improved understanding of precision farming tools, motivation to innovate, and demonstrated readiness for behavioral and managerial change (Senge, 1990). Interpretation remains preliminary, aiming to inform future extensive evaluations. Given the study's exploratory nature, limitations include small sample size and short intervention duration. Therefore, the findings presented here should be considered preliminary insights. Future research phases are planned to expand the units of analysis, extend the follow-up period, and conduct more comprehensive evaluations to assess the long-term sustainability, scalability, and impact of the BOOST vocational training model in precision agriculture. This phased approach ensures that the model can be refined and adapted based on robust longitudinal evidence before wider implementation.

To clarify the complementary roles of the quantitative and qualitative methods employed, we specify that this study uses quantitative surveys primarily to measure changes in knowledge, motivation, and perceived barriers, while qualitative analyses of the training session records explore learning dynamics, mentorship interactions, and psychological factors influencing adoption. This mixed-methods integration enhances validity and richness by triangulating measurable trends with contextualized insights.

Importantly, this study also proposes a replicable methodological framework for designing and evaluating VET programs in agribusiness and precision agriculture to facilitate adaptation across diverse agricultural contexts and contribute broadly to vocational education research. The methodological focus remains on process documentation and critical analysis of the training environments alongside outcome measurement.

Case description

The case study is set at Agricolt Brandoni, a farm located in Recanati, Marche Region, Italy (coordinates: 43.43525°N, 13.53729°E), at SP105, 84, 62019 Recanati (MC). Agricolt Brandoni is recognized for its advanced use of digital farming technologies, including satellite imagery, sensor networks, and decision support systems that enable optimized and sustainable crop management (Carolan, 2016).

Between March and April 2025, five on-farm theoretical-practical training sessions were conducted, each focusing on critical precision agriculture and agribusiness management topics. A summary of the sessions follows:

Session 1. *Introduction to Smart Farming Management: the entrepreneurial perspective, premises, and conditions for creating technological skills that translate into agricultural value:* Fundamental concepts were presented on which the proper management of a modern farm should be based, both from an economic and agronomic perspective, with reference to modern technologies that characterize precision agriculture.

Session 2. *Data management and processing for accurate soil knowledge and precision seeding; practical exercise on creating and reading prescription maps:* After an initial theoretical part explaining the methodology for acquiring soil data through geoelectrical surveys and the operation of the software for creating prescription maps for variable-rate seeding, participants observed the machinery used by the farm to apply the theoretical knowledge in practice.

Session 3. *Crop management from emergence to harvest; practical application exercise on machines with precision technology and data processing software:* Covered crop monitoring technologies using satellite and drone imagery, with a focus on precision irrigation systems.

Session 4. *Precision harvesting, yield analysis, and introduction to the Farm Management Information System (FMIS): how to create efficiency and effectiveness from data collection and analytical reading:* Trainees were able to confirm that digitization and data collection are essential and critical steps for enhancing the efficiency of a modern farm.

Session 5. *Parcel management and production cost analysis; focus on risk management as a business management tool integrated with precision technologies:* Cost analysis software, essential for efficiently managing all business activities and maintaining constant and dynamic updates on the farm's economic performance. Additionally, the topic of risk management was discussed, highlighting how it is a fundamental tool to be integrated with precision farming technologies to ensure managerial efficiency and effectiveness.

Along the development of these sessions, the training unit functioned as a learning laboratory, applying mentorship to transform the “problematic space” of farm management into a “learning space,” valuing trial-and-error experiences as key to effective learning (Scharmer, 2016).

Then, on May 27, 2025, a sixth mentorship session was held to validate the integrated effects of precision management techniques addressed in the previous five sessions and to support the development of personalized business models among trainees.

This session included:

A field evaluation on a maize case study: Assessing precision seeding integration with precision soil management, precision irrigation management, and the genetic innovations currently under testing.

A mentorship workshop: For collaborative idea development, problem-solving, and business planning oriented to technological farm management.

Business Challenge Call: Introducing and co-designing a template for drafting individual or team business models (Annex 4).

From May 27 to June 17, trainees independently developed business model drafts following the shared template. Trainees submitted their draft via email to the study coordinator, who forwarded them to Agricolt Brandoni mentors for tailored feedback. This iterative feedback encouraged continuous mentor-trainee dialogue, transforming business models into dynamic learning tools and reinforcing entrepreneurial skills grounded in real farm conditions (Yin, 2018).

Data collection and analysis

The assessment of the BOOST pilot training adopts a *mixed-methods longitudinal approach* grounded in Yin’s (2018) case study methodology, enabling an in-depth exploration of training effectiveness and learning trajectories within Agricolt Brandoni farm’s real-life context.

The sample included 16 trainees: farmers and entrepreneurs possessing varying degrees of expertise in precision agriculture, agricultural technicians, agronomists, and university students.

According to the BOOST framework, data were collected through three structured questionnaires administered at key training phases to capture evolving participant perceptions, knowledge, and feedback:

Ex-Ante questionnaire (Annex 1): baseline experience, entrepreneurial skills, expectations, and barriers.

In-Itinere questionnaire (Annex 2): mid-training progress, satisfaction, and challenges.

Ex-Post questionnaire (Annex 3): post-training competencies, motivation, and readiness for application.

Training sessions were audio-visually recorded and transcribed, a fundamental step that enabled detailed qualitative analysis and particularly enhanced the depth and accuracy of thematic coding related to mentorship dynamics and peer learning. To optimize the thematic coding process, the study employed Perplexity AI—an advanced research assistant facilitating semantic synthesis, pattern recognition, and transparent citation (BytePlus, 2025; Perplexity AI, 2025)—to systematically analyze all session transcripts and business model elaborations.[1]

The development of thematic Tables 5, 6, and 7 followed a structured process: initially, manual coding was performed by the research team to generate a draft of themes and preliminary categorizations, based on a comprehensive review of transcripts from training sessions and the participant business model elaborations before and after mentor feedback. This draft was then compared with a version generated by Perplexity AI, which, having processed the full transcripts and the trainees' business model elaborations, provided a synthesized thematic grouping and an independently developed coding structure.

Subsequently, the manual and AI-generated drafts were critically compared, with differences discussed and insights integrated to refine both codes and structural organization. The finalized thematic tables thus represent a triangulated integration of manual coding by the research team, AI-based synthesis, and mentors' evaluation. Only categorizations and thematic frameworks consistently supported by both human and AI analysis—and validated by mentors—were retained.

By integrating Perplexity AI into the research workflow, this study benefited from accelerated data collection, improved thematic synthesis, and enhanced triangulation between qualitative and quantitative evidence, collectively strengthening the methodological robustness and interpretative depth of the case study (BytePlus, 2025; Flick, 2018; Yin, 2018).[2]

While the integration of Perplexity AI with manual thematic coding enhanced depth,

---

[1] Perplexity AI's Deep Research functionality autonomously performs iterative searches, processes extensive datasets, and synthesizes comprehensive, coherent reports within minutes (BytePlus, 2025; Perplexity AI, 2025; ZDNET, 2025). This capability aligns with best practices in academic research, promoting rigorous integration of multi-source evidence and supporting the construction of well-founded, evidence-based analyses. Furthermore, Perplexity AI contributes to refining research questions, generating sub-questions, and assessing source reliability, thereby enhancing the cognitive rigor of the research process (Perplexity AI, 2025). Its transparent citation features facilitate critical evaluation of information validity and potential biases, which is important for maintaining scientific integrity.

[2] The sources cited for Perplexity AI include official documentation and authoritative descriptions from the developing company, BytePlus, as well as the official Perplexity AI platform. These sources ensure scientific reliability and transparency in the use of AI tools within the research process.

triangulation, and transparency, certain limitations should be acknowledged. The reliability of the AI-generated thematic framework was closely linked to the quality and completeness of input data and the interpretative engagement of the research team. The framework generated by Perplexity AI was validated in its overall structure and then systematically refined and optimized by the research team. This iterative and integrated approach ensured that final thematic categories were robust and empirically grounded. However, some domain-specific nuances and contextual subtleties inherent to qualitative agricultural training data may still be underrepresented.

Importantly, AI tools like Perplexity function as analytical aids rather than substitutes for human judgment and methodological oversight. Effective use of AI in scientific research requires recognizing it as a tool to augment—not replace—human expertise. Like decision-support systems in precision agriculture that provide valuable information yet defer final management decisions to human experts, AI assists data analysis under the researcher's guidance. The quality and validity of research outputs, including study design and interpretation, fundamentally depend on human expertise and judgment.

Going into the analysis of the questionnaire, data shows clear, substantial improvement in trainees' self-assessed competence in precision agriculture: low-experience participants dropped from 56% before training to zero after, while competent/very competent rose from 25% to 76%. The increase demonstrates the effectiveness of the experiential, mentorship-supported learning model (Table 1).

Table 1 - Experience and competence development

Phase	*Poor experience (%)*	*Moderate experience (%)*	*Good experience (%)*	*Very good experience (%)*
Ex-Ante	56	19	6	19
In-Itinere	13	31	31	25
Ex-Post	0	25	38	38

Table 2 - Familiarity with precision agriculture

Phase	*Not familiar (%)*	*Somewhat familiar (%)*	*Familiar (%)*	*Very familiar (%)*
Ex-Ante	0	25	44	31
In-Itinere	0	25	44	31
Ex-Post	0	19	38	44

Initially, 75% of trainees were "familiar" or "very familiar" with precision agriculture concepts, rising to 82% by training end, reflecting heterogeneous but solid prior knowledge requiring training to build deeper competencies (Table 2).

Persistent barriers include economic constraints (44%) and time/resource limitations (31-38%), with a slight rise in perceived technical and cultural obstacles, signaling increased awareness of adoption complexity. These align with literature on structural and cultural challenges, indicating the need for training that addresses technical skills alongside change management and economic support (Table 3).

Motivation to innovate increased from 56% to 69%; training satisfaction and perceived effectiveness score were very high at 88% and 94%, respectively, underpinning strong engagement and readiness to apply skills professionally (Table 4).

In summary, the questionnaire analysis indicates that the training and mentorship program played a crucial role in strengthening competencies, motivation, and awareness among participants, while also identifying areas for improvement to support broader and more sustainable adoption of precision agriculture technologies in future iterations.

Table 3 - Perceived barriers to adoption

Barrier Type	*Ex-Ante (%)*	*In-Itinere (%)*	*Ex-Post (%)*
Economic Costs	44	44	44
Training Time/Resources	31	38	38
Technical Complexity	25	31	31
Cultural/Psychological	19	25	25

Table 4 - Motivation, satisfaction, and perceived effectiveness

Aspect	*Ex-Ante (%)*	*In-Itinere (%)*	*Ex-Post (%)*
Motivation to Innovate	56	63	69
Satisfaction with Course	N/A	75	88
Perceived Effectiveness	N/A	81	94

Entering the thematic and coding analysis, an initial thematic coding draft was developed by the research team based on a session records "on the desk" analysis. This draft was then compared and iteratively refined through an interactive process with Perplexity AI, which analyzed the session transcripts to suggest optimized thematic groupings and emergent patterns related to learning dynamics, mentorship interactions, practical challenges, and entrepreneurial reflections (Bennis and Mouwafaq, 2025). The final set of *five key thematic dimensions* presented in Table 5 reflects the outcome of this integrated, human–AI analytical workflow, validated and finalized jointly by the research team and mentors. These are the core areas that capture the complexity and dynamics of the training experience as revealed by qualitative data analysis.

The training sessions revealed a *progressive knowledge-building process,* where participants moved systematically from understanding theoretical foundations toward applying practical skills. Early sessions focused on conceptual topics such as soil data mapping, which participants actively reflected upon during Session 2, gradually evolving into discussions of more complex technologies like precision irrigation in Session 3. This progression not only enhanced technical understanding but also promoted growing confidence among participants, highlighting the importance of scaffolded learning experiences combined with opportunities for reflection and dialogue.

Table 5 - Thematic and coding analysis of the training sessions

Theme	***Description***	***Illustrative examples from sessions***	***Implications for training design***

Progressive knowledge building	Movement from theoretical foundations to applied skills; growing participant confidence.	Participants reflect on soil data mapping during Session 2; discuss irrigation tech in Session 3.	Emphasize supported learning and reflection opportunities.
Practical challenges	Challenges with tools compatibility, data integration, and adapting workflows.	Frequent questions on equipment setup and software usability concerns.	Increase applied practice, software tutorials, and field visits.
Entrepreneurial thinking	Focus on cost-benefit analysis, risk management, and business model development.	Mentors guide cost analysis discussions; participants co-develop business plans.	Integrate economic modules and iterative business model coaching.
Peer-learning and co-creativity	Non-hierarchical mentorship fosters open dialogue and mutual learning among diverse participants.	Participants share experiences; mentors encourage collaborative problem-solving.	Maintain peer-based mentorship and encourage networking opportunities.
Psychological barriers	Recognition of cultural resistance and mental blocks toward adopting new technologies.	Discussions on farmer mindset; strategies to overcome skepticism.	Incorporate change management and motivational strategies in training.

Alongside this intellectual growth, participants faced *practical challenges* inherent in adopting new technologies. Common issues included equipment compatibility, difficulties integrating heterogeneous data streams, and adapting existing workflows to innovative tools. These challenges surfaced repeatedly through participants' questions about machinery setup and software usability concerns. Such feedback underscores the necessity of increasing hands-on practice components within the training, complemented by dedicated software tutorials and field visits, to bridge the gap between theory and real-world application. To meet these needs, one of the key mechanisms through which BOOST enhances innovation adoption is guided experimentation combined with expert mentorship. This approach allows agricultural entrepreneurs to gain confidence in precision technologies by better understanding how to adapt them to their specific conditions, which reduces perceived risk and facilitates adoption (Barnes et al., 2018).

A further dimension that emerged was *entrepreneurial thinking,* where participants, supported by mentors, engaged deeply with economic considerations such as cost-benefit analysis, risk management, and the iterative development of business models. Mentors played a pivotal role in guiding discussions around financial feasibility and encouraging co-development of viable business plans. This highlights the critical need to integrate economic modules and iterative coaching for business modelling within the training design, ensuring that technological adoption is paired with sustainable economic strategies.

The participatory, peer-based approach promoted trust, open dialogue, and mutual recognition, enhancing innovation adoption through co-creation and trainee engagement (Klerkx et al., 2012).

The next dimension that emerges relates to how the training environment promoted a culture of *peer learning and co-creativity* through non-hierarchical mentorship, encouraging open dialogue and mutual knowledge exchange among diverse participants. Trainees regularly shared experiences and solutions, while mentors facilitated collaborative problem-solving rather than top-down instruction. This dynamic was crucial in building trust and collective learning, highlighting the need for future programs to maintain peer-based mentorship and actively foster networking opportunities.

Finally, the analysis revealed the presence of *psychological barriers* that influence innovation adoption. Participants acknowledged cultural resistance within farming communities and internal mental blocks that can hinder openness to new technologies. Discussions often focused on understanding the farmer's mindset and strategizing ways to overcome skepticism and inertia. These insights point to the importance of incorporating change management principles and motivational strategies into the training curriculum, addressing not only technical skills but also the human and cultural dimensions of innovation adoption.

In sum, these five thematic dimensions provide a comprehensive framework for understanding how participants learn, the obstacles they face, and how to design mentorship to effectively support both technical and psychological aspects of innovation in precision agriculture. Embedding these insights into future training design will be essential to boost sustainable adoption and maximize the impact of precision agriculture technologies.

Moving into the applied design phase of the training, the mentorship analysis highlights four business models (Table 6) developed by trainees, representing diverse agricultural contexts and innovation paths. Each participant initially drafted an individual model reflecting a vision for integrating advanced technologies and sustainable practices into farm management.

In this phase, mentorship by the Agricolt Brandoni management team was pivotal for:

Technical validation and feasibility: mentors confirmed the practical applicability of proposed technologies such as automated micro-irrigation systems, sensor networks for environmental monitoring, drone and satellite imagery for crop health assessment, and biological inoculants like mycorrhizal fungi. This validation increased confidence in the "technical soundness" of the projects and helped tailor solutions to specific farm conditions, such as soil heterogeneity and water availability.

Table 6 - Trainee business models and mentor feedback

Business model	***Core idea***	***Key objectives***	***Mentor feedback highlights***
1. Multifunctional Vegetal Park (Student 1)	Multifunctional 5-hectare vegetal park integrating agriculture, tourism, education, and social activities; self-production of plant material; precision	Maximize productivity and experiential value; reduce water and energy waste; develop scientific tourism.	Emphasized economic viability through diversification; precision irrigation sensor technology applicable; satellite imagery useful for monitoring;

	agriculture for resource optimization.		economic decisions must lead agronomic ones.
2. Hill Farm Diversification (Student 2)	Dry hill farm with cereals and rotational high-value horticulture; precision farming tools like soil mapping, variable-rate seeding/fertilization, drone monitoring.	Autonomous management of key operations with precision tech; optimize inputs; maximize profitability.	Need for balanced farm size, mechanization, skilled labor; investment timing and critical obsolescence; access to credit and insurance schemes feasible; realistic planning essential.
3. MycoSystem Microirrigation (Student 3)	Precision micro-irrigation system delivering symbiotic mycorrhizal fungi; sensors monitor environmental parameters.	Reduce pesticide use; increase yield; safeguard biodiversity; foster innovation.	Technical feasibility confirmed; sensor integration and irrigation control required further study; drones/satellites complement monitoring; rapid prototyping encouraged.
4. Precision Cereals Management (Working group of 3 students)	Cereal-focused hill farm applying soil fertility mapping and variable-rate fertilization/seeding to optimize inputs giving the intra-field variability.	Improve production quality/quantity; reduce input waste; increase profitability.	Soil heterogeneity mapping fundamental; economic feasibility and ROI critical; mentorship supports agronomic and financial planning.

Economic and financial planning: mentorship guided trainees in developing realistic business plans, focusing on cost-benefit analysis of technology adoption. Mentors stressed the need to align farm size, mechanization, labor skills, and adopted technologies within a profitable economic-financial framework to ensure sustainability. They also pointed out funding opportunities from European and national programs and advised on risk management, including insurance.

Strategic market positioning: mentors encouraged participants to articulate clear market differentiation strategies based on sustainability, product traceability, and innovation. They stressed the value of communicating the environmental and quality benefits of precision agriculture to generate “premium prices” within differentiated markets and build consumer trust. The mentorship process was iterative and collaborative, transforming conceptual ideas into actionable farm strategies. However, it is also important to highlight that this phase remains ongoing, with tailored feedback encouraging business model maturation supporting by farm realities.

To further investigate the influence of mentorship on trainees' business model development, Table 7 illustrates the enhancements made from the original drafts to mentor-refined versions across technical, economic, operational, and strategic dimensions. The pilot mentorship phase supported the development of trainee business models into more robust, scalable, and market-oriented projects, bridging the gap between initial ideas and practical implementation.

Table 7 - Original vs. mentor-enriched business models

Aspect	*Original Models*	*Mentor-Enriched Models*
Technical feasibility	Conceptual application of precision tech; varying detail.	Confirmed applicability; tailored sensor and irrigation systems; drone/satellite integration.
Economic planning	Preliminary cost and revenue estimates.	Detailed business plans; investment sizing; funding strategies; risk management.
Market strategy	General focus on sustainability and innovation.	Clearer market differentiation; emphasis on traceability and premium positioning.
Operational detail	Broad operational goals.	Specific mechanization and workforce recommendations; operational timelines and scalability considered.
Collaborative feedback	Limited peer input.	Iterative refinement through mentor dialogue and practical insights.

Lessons learned:

- Precision agriculture technologies must be integrated with a thorough understanding of local agronomic conditions and economic constraints to be effective.
- Mentorship bridges the gap between conceptual innovation and practical implementation, providing critical expertise and contextual adaptation.
- Developing a comprehensive business plan that balances technical innovation with financial feasibility is essential for successful adoption.
- Collaborative learning environments enhance motivation and capacity building among emerging agricultural professionals.

Finally, trainees evaluated the mentorship phase. This ongoing evaluation aimed to capture the effectiveness, clarity, and impact of mentorship on their learning experience and entrepreneurial skills. To this end, we administered a structured questionnaire (Annex 5) to assess trainees' views on mentorship clarity, feedback usefulness, support in business modeling, mentor accessibility, and impact on confidence and motivation.

All categories scored highly (>4 out of 5), with confidence and motivation rated especially high, confirming mentorship's leading role in cultivating autonomy and entrepreneurial mindset (Table 8).

Table 8 - Trainees' ratings of mentorship effectiveness

Evaluated Aspects	*Average Rating (1-5)*
Clarity of guidance provided by mentors	4.5
Usefulness of feedback received	4.7
Support in business model development	4.3
Availability and accessibility of mentors	4.6
Impact on personal confidence and motivation	4.8

Conclusions

This study provides an initial assessment of the Italian BOOST Project's on-farm vocational training model in agribusiness and precision farming, emphasizing mentorship and participatory learning. The participant group included experienced professionals and advanced agricultural entrepreneurs, making the project an advanced-level course. Despite their prior expertise, even the most skilled trainees reported substantial benefits, demonstrating the program's capacity to deepen technical competence and entrepreneurial thinking across distinct experience levels. Overall, participants showed improvements in familiarity with precision farming tools and motivation to innovate, alongside high satisfaction with the training's practical relevance. At the same time, as awareness increases, participants' perception of the barriers to adopting precision agriculture also grows. It can be concluded that courses of this nature can create greater awareness among entrepreneurs, making them more conscious and prepared to adopt innovations within their companies.

This study aimed to address the central research question: *How can a participatory, on-farm vocational training model enhance learning effectiveness, foster innovation adoption, and stimulate entrepreneurial awareness in agribusiness and precision agriculture?* The findings demonstrate that the BOOST pilot, through embedded mentorship and participatory learning, effectively enhances learning by providing experiential, context-specific education that bridges theory and practice.

The empirical evidence presented supports the hypothesis that experiential, learning-by-doing approaches are effective (Gerster Bentaya et al., 2024). Mentorship played a key role in promoting collaborative innovation and the iterative refinement of business models. The participatory, peer-based framework established a dynamic learning environment characterized by trust, open dialogue, and mutual professional recognition, effectively bridging the gap between abundant commercial information and the applied, project-based skills necessary for real-world technology adoption. The study's methodological consistency was further strengthened by integrating qualitative and quantitative evidence in line with Yin's case study methodology, combining surveys, direct observation, and session transcripts to achieve a comprehensive, multi-dimensional understanding of the training process and its outcomes.

In addition to the quantitative and qualitative data elucidating the pilot's quality, effectiveness, and perceived validity, a crucial—though often overlooked—result is the practical demonstration that a farm can function as a true *learning laboratory*. Such environments offer fertile ground for innovation diffusion and skills development directly embedded in real farm contexts (Jackson-Smith and Veisi, 2023) and deserve further research, enhancement, and wider dissemination as a scalable educational model. This grassroots, high-level training approach presents a promising alternative to traditional academic settings, aligning with concepts of informal and empirical agriculture learning (Rogers, 2008; Marsden and Sonnino, 2008).

Importantly, the BOOST methodology exemplifies a virtuous application of the "Shifting the Burden" systems thinking model (Senge, 2006; Kim, 1992): rather than offering quick, symptomatic fixes, it promotes long-term, systemic capacity building through embedded mentorship and participatory learning. By transforming the farm into a "learning laboratory" and fostering the iterative co-creation of business models and innovation strategies, BOOST shifts the focus from temporary interventions to durable, systemic adaptation. Here, ongoing experiential and peer-to-peer learning enables participants not only to acquire skills but also to help transform organizational culture and drive change from within (Senge et al., 2008).

However, for BOOST to realize its full, transformative potential and avoid becoming a short-term or isolated fix—to truly *shift the burden* systemically—it must be maintained as a continuous, integrated educational process within a broader innovation ecosystem that supports economic, infrastructural, and cultural transformation. If applied merely as an episodic intervention, it risks falling into the original systemic *shifting-the-burden trap*, where only immediate gaps are addressed, leaving underlying challenges unresolved and undermining the long-term sustainability of innovation.

To maximize its impact, BOOST should be positioned within multi-level strategies targeting structural, cultural, and economic barriers to change. Such integration ensures that training becomes not just a temporary remedy but a lasting catalyst for resilience, adaptability, and systemic innovation in agriculture.

Furthermore, the complex pressures of global economic shifts, generational change, and climate variability provide an opportunity to rethink the role of the agricultural entrepreneur. Future farmers will need to increasingly embrace innovation, adaptability, and strategic vision—including digital skills, sustainable practices, and an entrepreneurial mindset—to respond effectively to evolving challenges. The BOOST training model, as demonstrated in this case study, contributes to this ongoing transition by supporting targeted education grounded in mentorship, experiential learning, and peer collaboration. While further research is needed, such approaches may help develop more resilient and forward-looking agricultural systems, capable of continuous adaptation.

A key strength of this study lies in its replicability and transparency: all research materials—including questionnaires, business model templates, and coding frameworks—are available to the research community, and audio recordings may be shared upon request. The research team also encourages collaboration with others interested in replicating or extending the BOOST model, facilitating shared progress in vocational agricultural training.

Looking ahead, future research should expand the participant base, extend follow-up periods, and refine evaluation tools to better assess long-term sustainability and scalability. Integrating modules focused on change management and economic support is also recommended to address systemic barriers more effectively. The methodological framework developed through this study offers a transferable model for designing and evaluating vocational training in diverse agricultural contexts, further advancing precision farming education.

Acknowledgments

This paper was funded by the BOOST project, an Erasmus+ program of the European Union. Funded by the European Union (101056291 - EDU-2021-PI-ALL-INNO). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

References

Alexandratos, N. & Bruinsma, J. (2012). *World agriculture towards 2030/2050: The 2012 revision*. ESA Working Paper No. 12-03. Rome: Food and Agriculture Organization of the United Nations (FAO). Retrieved July 5, 2025, from https://www.fao.org/3/ap106e/ap106e.pdf

Barnes, A., Soto Embodas, I., Eory, V., Beck, B., Balafoutis, A., Sanchez Fernandez, B., … Gomez Barbero, M. (2018). Exploring the adoption of precision agricultural technologies: a cross regional study of EU farmers. *Land Use Policy*, 80, pp.163–174. https://doi.org/10.1016/j.landusepol.2018.10.004

Bennis, I., & Mouwafaq, S. (2025). Advancing AI-driven thematic analysis in qualitative research: a comparative study of nine generative models on Cutaneous Leishmaniasis data. *BMC Medical Informatics and Decision Making* 25, 124 (2025). https://doi.org/10.1186/s12911-025-02961-5

BytePlus (2025) *Perplexity AI API documentation*. Retrieved July 5, 2025, from https://www.byteplus.com/en/topic/536561

Carolan, M. (2016) *The sociology of food and agriculture*. Routledge, London.

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J. & Neville, A.J. (2014). The use of triangulation in qualitative research. *Oncology Nursing Forum*, 41(5), pp. 545–547. https://doi.org/10.1188/14.ONF.545-547

Denzin, N.K. (2009) *The research act: a theoretical introduction to sociological methods*. Aldine Transaction, New Brunswick.

Flick, U. (2018) *An introduction to qualitative research*. 6th edn. Sage Publications, London.

Gerster Bentaya, M., Maes, O., Rembold, F. & Callenius, C. (2024). *Agricultural Extension and Advisory Services in Low and Lower-Middle-Income Countries - Knowledge Review*. European Commission, Ispra. JRC137791. Retrieved July 5, 2025, from https://publications.jrc.ec.europa.eu/repository/bitstream/JRC137791/JRC137791_01.pdf

Jackson-Smith, D., & Veisi, H. (2023). A typology to guide design and assessment of participatory farming research projects. *Socio-Ecological Practice Research* 5, 159–174 (2023). https://doi.org/10.1007/s42532-023-00149-7

Kim, D.H. (1992). *Systems Archetypes I: Diagnosing Systemic Issues and Designing High-Leverage Interventions.* Pegasus Communications, Inc.

Klerkx, L., van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions. In: Darnhofer, I., Gibbon, D., Dedieu, B. (eds) *Farming Systems Research into the 21st Century: The New Dynamic*. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4503-2_20

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS - Wageningen Journal of Life Sciences*, 90-91, 100315. https://doi.org/10.1016/j.njas.2019.100315

Kolb, D.A. (1984) *Experiential learning: experience as the source of learning and development*. Prentice Hall, Englewood Cliffs.

Marsden, T. & Sonnino, R. (2008). Rural development and the regional state: denying multifunctional agriculture in the UK. *Journal of Rural Studies*, 24(4), pp. 422–431. https://doi.org/10.1016/j.jrurstud.2008.04.001

Mulder, M. (2017). A Five-Component Future Competence (5CFC) Model. *The Journal of Agricultural Education and Extension*, *23*(2), 99–102. https://doi.org/10.1080/1389224X.2017.1296533

OECD (2025) *Environmental Performance of Agriculture in OECD Countries: Key Trends and Insights*. Paris: OECD Publishing. Retrieved July 5, 2025, from https://www.oecd.org/en/publications/environmental-performance-of-agriculture-in-oecd-countries_2679ba38-en.html

Perplexity AI (2025) *Introducing Perplexity Deep Research*. Retrieved July 5, 2025, from https://www.perplexity.ai/hub/blog/introducing-perplexity-deep-research

Rogers, E.M., Singhal, A., & Quinlan, M.M. (2008). *Diffusion of innovations*. In: An Integrated Approach to Communication Theory and Research. 2nd edn, Routledge.

Scharmer, O.C. (2016). *Theory U: leading from the future as it emerges*. 2nd edn. Berrett-Koehler Publishers, San Francisco.

Senge, P.M. (2006). *The fifth discipline: the art and practice of the learning organization*. Random House Business Books, London.

Senge, P.M., Smith, B., Kruschwitz, N., Laur, J. & Schley, S. (2008). *The necessary revolution: how individuals and organizations are working together to create a sustainable world*. Doubleday, New York.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.J. (2017). Big data in smart farming: a review. *Agricultural Systems*, 153, pp. 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

World Bank (2024). *The World Bank's Support for Repurposing of Agrifood Public Policies and Programs: Moving from Advocacy to Action*. Washington, D.C.: The World Bank. Retrieved July 5, 2025, from https://thedocs.worldbank.org/en/doc/3da165e0bcb0ed7dddba9939afb21fda-0590012023/related/The-World-Bank-s-Support-for-Repurposing-of-Agrifood-Public-Policies-and-Programs-Sep-2024.pdf

Yin, R.K. (2018). *Case study research and applications: design and methods*. 6th edn. Sage Publications, Inc., Los Angeles.

Zarco-Tejada, P.J., Hubbard, N. & Loudjani, P. (2014). Precision agriculture: an opportunity for EU farmers: potential support with the CAP 2014-2020. *European Parliament*, Brussels. Retrieved July 5, 2025, from http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT(2014)529049_EN.pdf

ZDNet (2025). What is Perplexity Deep Research, and how do you use it? *ZDNet*. Retrieved July 5, 2025, from https://www.zdnet.com/article/what-is-perplexity-deep-research-and-how-do-you-use-it/