E-demofarm as an Integrated Framework for Education, Training and Extension in Precision Viticulture

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Abstract.

The demonstration farm has historically played a central role in agricultural education and technology transfer by providing tangible environments where innovation is applied in practice. Traditional models, however, are limited by geographic and accessibility constraints and by insufficient integration of digital technologies, which restricts the widespread dissemination of innovation and practical training. To overcome these barriers, the e-demofarm was developed and examined within the VTskill project in the Mediterranean viticulture context as a digital advancement of the traditional demonstration farm. The e-demofarm integrates real production environments with advanced sensing technologies, including IoT, proximal and remote sensors, and unmanned aerial systems, as well as data platforms and advanced analytics. This system demonstrates, validates, and transfers innovations under real operating conditions through both physical and virtual modalities.

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Within the e-Demofarm framework, the virtual component consists of structured, web-based practical exercises that complement field-based demonstration activities. These exercises allow *learners to engage directly with real datasets and operational scenarios, including generating NDVI-based prescription maps, assessing machinery performance, and evaluating application quality through guided analytical workflows. Instead of utilizing a virtual assistant, the virtual environment serves as an interactive learning platform in which users actively perform data-driven tasks that replicate real decision-making processes in precision viticulture.*

The e-demofarm model is designed to strengthen digital and environmental competencies, facilitate the adoption of data-driven agricultural practices, and improve the integration of technological innovation with practical field training. It has directly supported the training of 200 learners from higher education and vocational education and training (VET) programs across five European countries. Through hands-on engagement with authentic agronomic datasets and operational scenarios, learners acquire the ability to independently process agronomic data, critically assess spatial variability, and translate analytical outputs into operational recommendations. As a result, the e-demofarm demonstrates considerable potential as a reference model for modern agricultural training ecosystems and for advancing sustainable, data-driven vineyard management practices.

Keywords.
Precision Agriculture, Education, Technology Transfer, Precision Viticulture.

Introduction

Demonstration farms have long been recognised as tools for agricultural education, knowledge exchange, and innovation dissemination within extension systems and, more recently, within Agricultural Knowledge and Innovation Systems (AKIS) (Burton, 2020; Heiniger et al., 2002; Ingram et al., 2018; Ingram et al., 2021; Sutherland et al., 2021). They provide practical environments where farmers and stakeholders can observe, discuss, and evaluate new technologies, management practices, and production strategies under real farming conditions (Adamsone-Fiskovica et al., 2021; Bailey et al., 2006; Heiniger et al., 2002; De Witte et al., 2023). By offering tangible evidence of innovation performance and applicability, demonstration farms reduce uncertainty around adopting new practices and support informed decision-making (Burton, 2020; Heiniger et al., 2002; De Witte et al., 2023).

Contemporary demonstration farms are increasingly seen as interactive learning spaces that connect farmers, advisors, researchers, students, and other stakeholders within agricultural innovation networks (Ingram et al., 2018; Ingram et al., 2021; Sutherland et al., 2021). Through observation, discussion, and peer-to-peer exchange, they promote experiential learning, enabling participants to acquire practical skills, critically reflect on farming practices, and build confidence in implementing innovations (Adamsone-Fiskovica et al., 2021; De Witte et al., 2023; Ingram et al., 2018; Kilpatrick and Johns, 2003; Marchand et al., 2021). As a result, demonstration farms support not only knowledge transfer but also behavioural change, innovation adoption, and the transition to more sustainable agricultural systems (De Witte et al., 2023; Ingram et al., 2018; Marchand et al., 2021; Prager et al., 2017).

Despite their importance, traditional demonstration farms face significant limitations (Adamsone-Fiskovica et al., 2021; Sutherland et al., 2021). They require substantial economic and logistical resources, including land, equipment, and dedicated staff (De Witte et al., 2023; Adamsone-Fiskovica et al., 2021). Spatial constraints limit accessibility to those able to attend in person (Heiniger et al., 2002; Sutherland et al., 2021). While on-site knowledge transfer is effective, it is difficult to scale beyond local contexts, and opportunities for ongoing interaction with data and decision-making are limited (Adamsone-Fiskovica et al., 2021; Bailey et al., 2006; Prager et al., 2017). These challenges are especially relevant in precision agriculture, which requires flexible, scalable learning infrastructures to support broad access to training and experimentation (Heiniger et al., 2002; De Witte et al., 2023; Sutherland et al., 2021).

Virtual learning environments have become valuable complements to physical demonstration farms (De Witte et al., 2023; Bailey et al., 2006; Ingram et al., 2018). Digital platforms replicate key aspects of experiential learning while overcoming spatial, temporal, and economic barriers (Sutherland et al., 2021; De Witte et al., 2023; Heiniger et al., 2002). They can reach geographically dispersed learners, use diverse instructional resources, and integrate real or simulated data from advanced sensing systems (Heiniger et al., 2002; Ingram et al., 2018). Virtual environments also support iterative experimentation in controlled settings, strengthening decision-making, data interpretation, and technology adoption skills (De Witte et al., 2023; Heiniger et al., 2002; Sutherland et al., 2021).

The e-demofarm offers a new model that combines the strengths of physical demonstration farms with the scalability and interactivity of digital environments. Developed through the VTskills project in Mediterranean viticulture, the e-demofarm integrates physical demonstration activities with virtual learning and data-driven training. This paper outlines the development of the e-demofarm framework, key lessons from existing initiatives, and its implementation in sustainable precision viticulture education.

Methodology

A preliminary assessment of demonstration farm initiatives identified key success factors, operational challenges, and opportunities for future development. The analysis combined desk research with a stakeholder survey of organisations that manage or coordinate demonstration farm activities across Europe.

The analysis sought to identify success factors and limitations of traditional demonstration farm models, understand stakeholder needs, highlight effective knowledge exchange practices, and assess the potential of digital and hybrid approaches to enhance impact and scalability. Twenty-one organisations from France, Greece, Italy, and Spain participated, representing private companies, research centres, universities, and public organisations (Fig. 1).

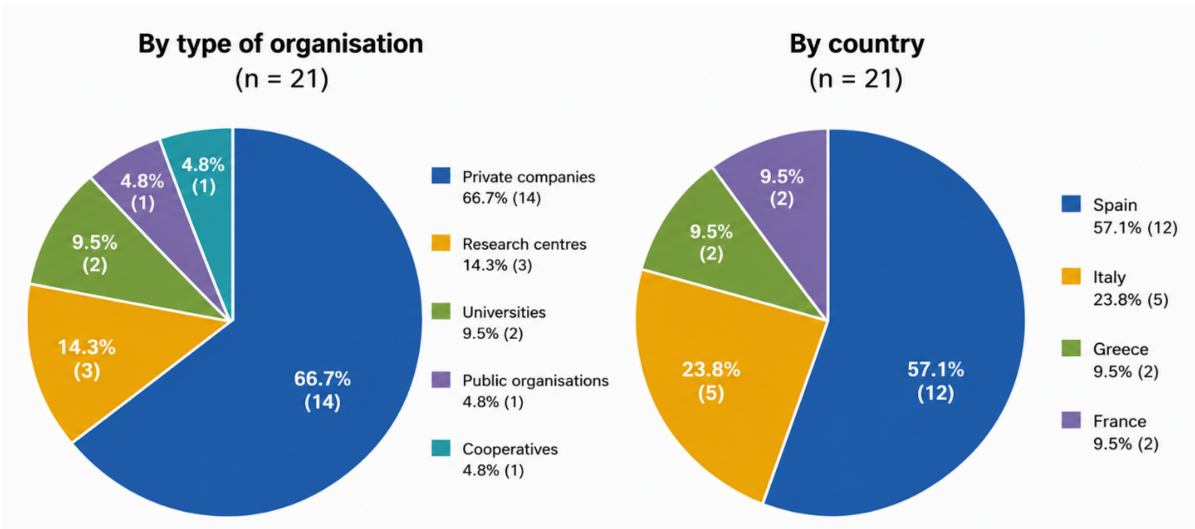

Fig. 1. Profile of the 21 organisations that participated in the survey, by the type of organization and by country.

The findings were analysed to identify recurring themes in knowledge exchange, innovation adoption, participant engagement, operational constraints, and digitalisation. These insights informed the conceptual design and functional requirements of the VTskills e-demofarm framework.

The e-demofarm framework was developed within the Erasmus+ VTskills project to strengthen entrepreneurial, digital, and green competences in Sustainable Precision Viticulture. It complements traditional demonstration farm activities by integrating digitally supported learning experiences, enabling participants to engage with real-world agricultural data and decision-making while maintaining a strong connection to operational farming conditions.

The design process drew on three sources: analysis of existing demonstration farm initiatives, the educational objectives of the VTskills training programme, and the competence requirements for sustainable precision viticulture. The process addressed limitations of traditional demonstration activities, such as geographical constraints, weather dependency, limited scalability, and challenges in maintaining learner engagement. This information defined the pedagogical and functional requirements for the e-demofarm framework.

Following its development, the e-demofarm framework was integrated into the VTskills training programme and prepared for implementation with approximately 200 participants from four European countries, including Higher Education Institutions (HEI) and Vocational Education and Training (VET) learners, as well as professionals from the viticulture sector who participated in the VTskills training programme on Sustainable Precision Viticulture. The framework was deployed through a commercial digital platform adapted for educational purposes, providing learners with access to digital resources, real-world datasets, and guided learning experiences

(Figure 2).

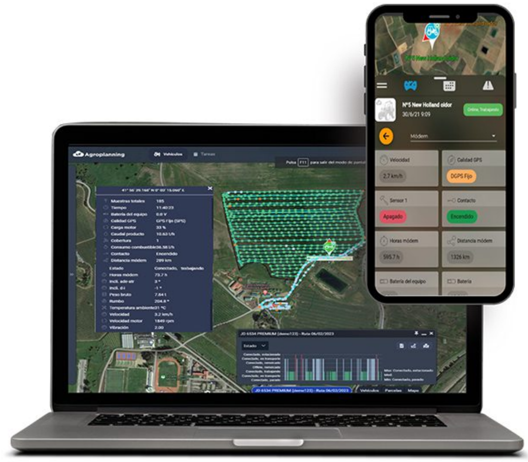

Fig. 2. My Vitiplanning platform for precision viticulture, providing real-time monitoring and management of vineyard operations through an integrated web and mobile interface. The system enables visualization of machinery location, operational parameters, field activities, and telematics data, supporting data-driven decision-making and improved vineyard management efficiency.

Results

The analysis of existing demonstration farm initiatives highlighted the important role these environments play in agricultural knowledge transfer, dissemination of innovation, and stakeholder engagement (Table 1).

Table 1. Main strengths and challenges identified from the survey of demonstration farm organisations (n=21)

STRENGTHS & OPPORTUNITIES	CHALLENGES IDENTIFIED BY RESPONDENTS	FREQUENCY	% OF ORGANISATIONS
Knowledge exchange and technological advancement	Communication and participant engagement issues	12	57.1%
Problem-solving through real-world applications	Weather-related constraints	10	47.6%
Networking and community-building across the EU	Logistical complexity of organising events	9	42.9%
Research collaboration and access to innovation	Low attendance and participation rates	8	38.1%

Participants could select more than one challenge; therefore, percentages do not sum to 100%.

Respondents consistently identified demonstration farms as valuable platforms for knowledge exchange, technological advancement, networking, and research collaboration. However, several operational challenges were also reported. Communication and participant engagement issues were the most frequently cited obstacles (57.1%), followed by weather-related constraints (47.6%), logistical complexity (42.9%), and low attendance rates (38.1%). These findings reveal that, while demonstration farms are highly valued as learning and innovation environments, their effectiveness can be limited by organisational and contextual factors that affect accessibility, continuity, and participant involvement.

Overall satisfaction with organising demonstration farm activities was high, with a mean score of 4.24 ± 0.77 on a five-point scale (median = 4, range = 3–5), confirming a positive perception of demonstration farms as effective tools for knowledge transfer and the dissemination of innovation.

To identify which educational approaches generate the highest levels of engagement and learning, respondents were asked to indicate the activities they considered most effective for knowledge exchange and technology transfer (Fig. 3). Field demonstrations were perceived as the most effective activity, selected by 95.2% of organisations, followed by guided visits (76.2%). In comparison, interactive discussions and question-and-answer sessions were chosen by 42.9% of respondents, while technology presentations were identified by 38.1%. These results indicate a clear preference for experiential, hands-on learning approaches, where participants directly observe technologies and management practices under real-world operating conditions. The findings reinforce the significance of active participation and real-world problem-solving as essential components of successful demonstration activities.

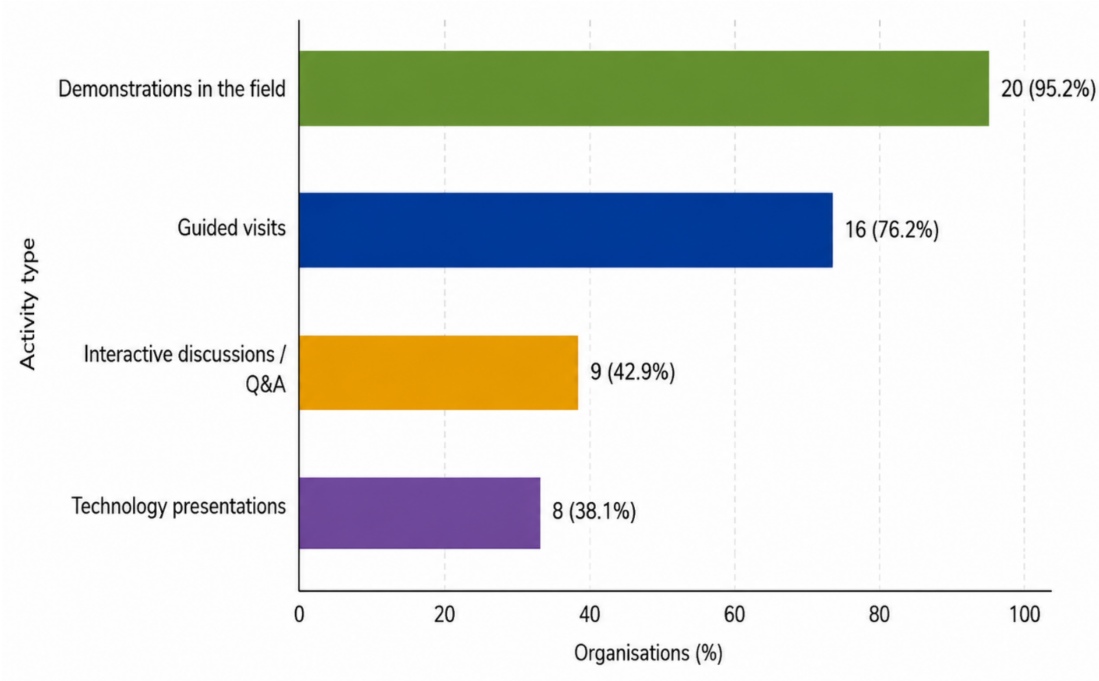

Fig. 3. Most effective activities for knowledge exchange according to surveyed organizations.

Respondents also identified several educational approaches that were perceived as less effective for knowledge exchange and participant engagement (Fig. 4). Long theoretical presentations were the most frequently cited limitation (71.4%), followed by passive observation activities (52.4%). Logistically complex activities (38.1%) and activities with limited educational value (23.8%) were reported less frequently. These findings suggest that educational approaches based primarily on passive information transfer are considerably less effective than those promoting direct participation and experiential learning. The results further support the need for learner-centred educational environments that encourage active engagement, interaction, and practical problem-solving.

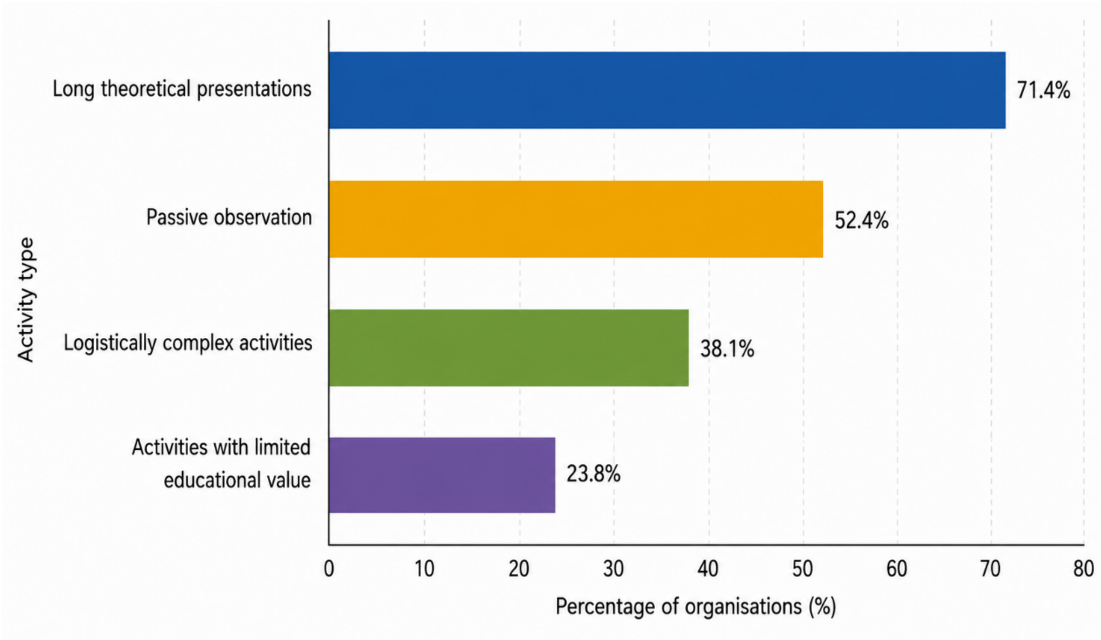

Fig. 4. Educational activities perceived as least effective for knowledge exchange and participant engagement.

Organisations were also asked to identify measures that could improve participation and engagement in demonstration activities (Fig. 5). Increasing the number of interactive activities was overwhelmingly recognised as the most effective strategy (90.5%), followed by improving communication before events (71.4%). Additional participant guidance (28.6%) and incentives or rewards (14.3%) were mentioned less frequently. These findings highlight the importance of active learner involvement and continuous interaction as key elements for enhancing the effectiveness of demonstration-based learning environments.

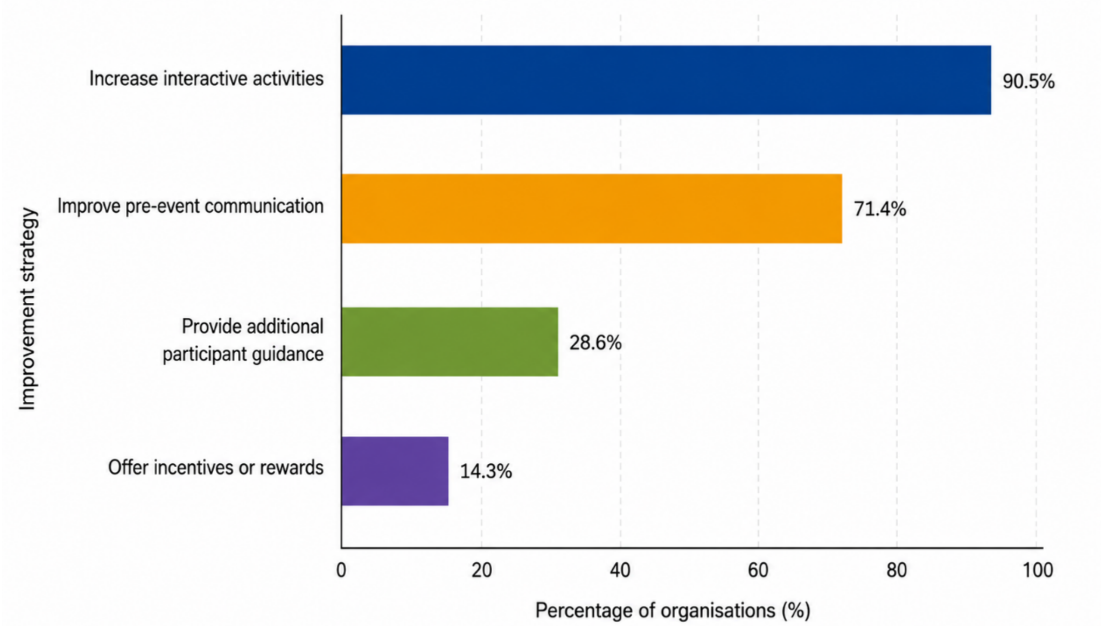

Fig. 5. Strategies identified by surveyed organisations to improve participation and engagement in demonstration farm activities.

To address the limitations identified through the survey, the e-demofarm was developed as an integrated learning environment combining physical demonstration farms and digital learning resources. The physical component consists of operational vineyards located in Spain, France, Italy and Greece, where technologies and management practices are demonstrated under real production conditions. The digital component provides access to authentic agronomic datasets, enabling learners to explore variability, analyse management scenarios and understand data-driven decision-making processes.

Educational activities are organised through challenge-based learning scenarios derived from real demonstration farm situations. Learners analyse operational datasets, evaluate management alternatives and develop recommendations using precision viticulture tools such as machinery performance assessment, NDVI-based prescription mapping and field operation quality analysis. This approach promotes technical, analytical and decision-making competencies while extending participation and accessibility beyond conventional field-based events.

Discussion

The survey results confirm that demonstration farms are widely perceived as effective environments for agricultural knowledge transfer, innovation dissemination, and stakeholder engagement, as reflected by the high overall satisfaction score reported by participating organisations (4.24 ± 0.77 on a five-point scale). However, respondents also highlighted important operational limitations, particularly communication and participant engagement issues (57.1%), weather dependency (47.6%), logistical complexity (42.9%), and low attendance rates (38.1%). These findings indicate that, while demonstration farms provide valuable experiential learning opportunities, their educational impact may be constrained by factors that limit accessibility, scalability, and continuity.

A key outcome of the survey was the strong preference for active and experiential learning approaches. Field demonstrations (95.2%) and guided visits (76.2%) were consistently identified as the most effective knowledge exchange activities, whereas long theoretical presentations (71.4%) and passive observation approaches (52.4%) were perceived as considerably less effective. These results align with contemporary educational theories that emphasise active learning, experiential learning, and problem-based approaches as effective mechanisms for developing professional competencies. The findings suggest that learners derive greater value from educational experiences that involve direct interaction with technologies, real-world situations, and practical decision-making processes.

The survey also revealed clear recommendations for improving demonstration-based learning. Increasing interactive activities was identified by 90.5% of organisations as the most effective strategy for enhancing participation and engagement, followed by improved communication before events (71.4%). These results directly informed the design of the e-demofarm framework. Rather than replicating traditional demonstration activities in a digital format, the e-demofarm seeks to preserve the experiential value of demonstration farms while extending participation opportunities through continuous access to authentic datasets, management scenarios, and challenge-based learning activities.

The proposed framework addresses several limitations identified in traditional demonstration farms. By integrating digital resources with physical demonstration sites, learners can engage with real-world production data independently of seasonal constraints, geographical distance, or event scheduling. This approach enhances accessibility while maintaining a strong connection to practical agricultural conditions. Furthermore, challenge-based learning activities encourage learners to interpret information, evaluate alternative management strategies, and formulate evidence-based recommendations, thereby promoting higher-order analytical and decision-making skills that are increasingly required in precision agriculture.

Beyond precision viticulture, the framework illustrates how demonstration-based learning can evolve within increasingly digital and data-intensive agricultural systems. Modern agricultural professionals must not only understand technologies but also analyse complex datasets, assess management alternatives, and make informed decisions under varying agronomic conditions. The integration of operational farm data, digital learning environments, and challenge-based educational activities offers a scalable pathway for developing these competencies while preserving the practical orientation that makes demonstration farms valuable learning environments.

Several challenges remain for the long-term implementation of e-demofarms. Maintaining access to reliable and up-to-date datasets requires sustained collaboration with demonstration farm operators, researchers, and technology providers. Likewise, educational resources and analytical workflows must evolve alongside advances in digital agriculture and precision farming technologies. Institutional commitment, technical infrastructure, and educator training will therefore play a critical role in ensuring the successful adoption and sustainability of digitally enhanced demonstration environments.

Although developed within the context of sustainable precision viticulture, the principles underpinning the e-demofarm framework are broadly transferable to other agricultural sectors. Combining demonstration sites, authentic operational datasets, and challenge-based learning activities represents a promising strategy for supporting competence development in the increasingly data-driven agricultural systems that characterise modern farming.

Conclusion

The survey confirmed that demonstration farms are highly valued as environments for knowledge transfer, innovation dissemination, and experiential learning, achieving a high overall satisfaction score (4.24 ± 0.77). However, respondents also identified important limitations related to communication, participant engagement, logistical complexity, weather dependency, and accessibility.

The results revealed a clear preference for active and practice-oriented learning approaches. Field demonstrations (95.2%) and guided visits (76.2%) were identified as the most effective educational activities, whereas long theoretical presentations (71.4%) and passive observation approaches (52.4%) were perceived as less effective. Furthermore, increasing interactive activities (90.5%) and improving communication (71.4%) were identified as the most relevant strategies for enhancing participation and engagement.

These findings directly informed the design of the e-demofarm framework, which combines physical demonstration sites, digital resources, and challenge-based learning activities within a unified educational environment. By extending access to authentic datasets, real-world scenarios, and decision-making processes beyond conventional field events, the framework aims to preserve the experiential value of demonstration farms while improving accessibility, continuity, and scalability.

Although developed for Sustainable Precision Viticulture, the e-demofarm concept provides a transferable model for supporting competence development in increasingly digital and data-driven agricultural systems. Future work should focus on evaluating learning outcomes, learner engagement, and the long-term contribution of e-demofarms to professional training and innovation adoption.

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References

Adamsone-Fiskovica, A., Grivins, M., Burton, R. J., Elzen, B., Flanigan, S., Frick, R., & Hardy, C. (2021). Disentangling critical success factors and principles of on-farm agricultural demonstration events. The Journal of Agricultural Education and Extension, 27(5), 639-656.

Bailey, A. P., Garforth, C. J., Angell, B., Scott, T., Beedell, J., Beechener, S., & Rana, R. B. (2006). Helping farmers adjust to policy reforms through demonstration farms: lessons from a project in England. Journal of Farm Management, 12(10), 613-625.

Burton, R. J. (2020). The failure of early demonstration agriculture on nineteenth century model/pattern farms: lessons for contemporary demonstration. The Journal of Agricultural Education and Extension, 26(2), 223-236.

De Witte, R., Janssen, D., Sayadi Gmada, S., & García-García, C. (2023). Best practices for training in sustainable greenhouse horticulture. Sustainability, 15(7), 5816.

Heiniger, R. W., Havlin, J. L., Crouse, D. A., Kvien, C., & Knowles, T. (2002). Seeing is believing: The role of field days and tours in precision agriculture education. Precision Agriculture, 3(4), 309-318.

Ingram, J., Chiswell, H. M., Mills, J., Debruyne, L., Cooreman, H., Koutsouris, A., ... & Marchand, F. (2018). Enabling learning in demonstration farms: A literature review. International Journal of Agricultural Extension, 2018, 29-42.

Ingram, J., Chiswell, H., Mills, J., Debruyne, L., Cooreman, H., Koutsouris, A., ... & Marchand, F. (2021). Situating demonstrations within contemporary agricultural advisory contexts: analysis of demonstration programmes in Europe. The Journal of Agricultural Education and Extension, 27(5), 615-638.

Kilpatrick, S., & Johns, S. (2003). How farmers learn: Different approaches to change. The Journal of Agricultural Education and Extension, 9(4), 151-164.

Marchand, F., Cooreman, H., Pappa, E., Perifanos, I., Alexopoulos, Y., Debruyne, L., ... & Koutsouris, A. (2021). Effectiveness of on-farm demonstration events in the EU: role of structural characteristics. The Journal of Agricultural Education and Extension, 27(5), 677-697.

Prager, K., & Creaney, R. (2017). Achieving on-farm practice change through facilitated group learning: Evaluating the effectiveness of monitor farms and discussion groups. Journal of Rural Studies, 56, 1-11.

Sutherland, L. A., Burton, R. J., Adamsone-Fiskovica, A., Hardy, C., Elzen, B., Debruyne, L., & Flanigan, S. (2021). Inclusivity of on-farm demonstration: gender, age, and geographic location. The Journal of Agricultural Education and Extension, 27(5), 591-613.