JPPIPA 12(4) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Integrating Science and Entrepreneurial Character Among Islamic Boarding School Students Through an Integrated Agribusiness Model

Afiful Ihwan[1*], Wahidmurni[1], Jamiluddin Yacub[1]

[1] UIN Raden Fatah Palembang, Palembang, Indonesia.

Received: February 22, 2026
Revised: March 27, 2026
Accepted: April 25, 2026
Published: April 30, 2026

Corresponding Author:
Afiful Ihwan
afifulihwan995@gmail.com

DOI: 10.29303/jppipa.v12i4.15058

Abstract: This study analyzes the integration of scientific knowledge and entrepreneurial character development among *santri* (Islamic boarding school students) through an integrated agribusiness model at two *pesantren* in East Ogan Komering Ulu, Indonesia. Using a qualitative case study approach with interviews, observation, and document analysis, findings reveal that both institutions systematically combine scientific agricultural practices—such as hydroponics, organic cultivation, and sustainable resource management—with Islamic ethical principles like *amanah* (trustworthiness) and *muamalah fiqh*. Three core strategies emerged: value-infused mentorship, reflective practice, and community-engaged learning, which collectively cultivate a distinctive "santripreneur" identity wherein scientific literacy, economic agency, and spiritual accountability mutually reinforce one another. *Santri* demonstrated enhanced entrepreneurial self-efficacy, innovation orientation, evidence-based decision-making, and ethical reasoning. The study concludes that integrated agribusiness models effectively internalize entrepreneurial character when grounded in experiential learning, science-based pedagogy, and value-based instruction. However, scalability requires addressing systemic constraints—including technological access, market linkages, and educator capacity—through coordinated multi-stakeholder support. These insights offer a replicable framework for Islamic educational institutions seeking to cultivate ethically grounded, scientifically literate, and economically resilient graduates capable of contributing to sustainable rural development.

Keywords: Boarding school; Entrepreneurial Character; Islamic; Science.

Introduction

Islamic boarding schools (*pesantren*) in Indonesia have historically served as foundational institutions for religious, moral, and character education (Ikuemonisan et al., 2022; Romani et al., 2023). Beyond their spiritual mission, their strategic placement in rural regions, access to agricultural land, and concentration of young learners position them as potential hubs for science-based economic innovation (Conte et al., 2025; Houser et al., 2026; Machado et al., 2024). In an era demanding scientific literacy, ecological sustainability, and economic adaptability, equipping *santri* with both ethical grounding and practical competencies in agricultural science and entrepreneurship has become essential (Calafat-Marzal et al., 2025; Melo et al., 2026; Ngarava, 2026). Integrating scientific knowledge—such as agronomic principles, integrated resource management, hydroponic systems, and data-informed production planning—into entrepreneurial character development offers a viable pathway to cultivate resilient, innovative, and values-driven graduates who can contribute to regional food security and sustainable rural economies (Olivera et al., 2022; Prioli Duarte et al., 2023; Uyar et al., 2024).

Despite this potential, many *pesantren* face challenges in systematically embedding scientific inquiry and entrepreneurial values into their daily educational routines (Carbajal et al., 2025; Modica et al., 2025; Shen et al., 2026). The absence of structured

How to Cite:
Ihwan, A., Wahidmurni, & Yacub, J. (2026). Integrating Science and Entrepreneurial Character Among Islamic Boarding School Students Through an Integrated Agribusiness Model. *Jurnal Penelitian Pendidikan IPA*, *12*(4), 297–306. https://doi.org/10.29303/jppipa.v12i4.15058

pedagogical models that seamlessly align Islamic ethics, agricultural science, and market-oriented thinking often limits the effectiveness of character internalization (Adeniji et al., 2025; Jin et al., 2022; Tanaka et al., 2025). Additionally, constraints such as limited technical expertise, inadequate access to modern scientific tools, and fragmented curricular design hinder the consistent development of scientifically literate, entrepreneurial mindsets among students (Dohou et al., 2026; Ramos Collin et al., 2024; Zhang et al., 2025). Addressing these gaps requires a deliberate, context-sensitive approach that bridges spiritual formation, experiential science learning, and practical agribusiness engagement (Amoabeng-Nimako et al., 2025; Bakas et al., 2025; Duncan et al., 2026).

This study aims to analyze how scientific knowledge and entrepreneurial character are integrated among *santri* through an integrated agribusiness model. Focusing on Pondok Pesantren Nurussalam and Darul Falah in East Ogan Komering Ulu, the research seeks to identify the educational strategies, curricular integrations, and practical implementations employed to foster scientific literacy, entrepreneurial attitudes, and ethical decision-making. By examining how these institutions combine Islamic values with science-based agribusiness training, this work clarifies the operational dynamics that enable effective character development, providing a foundational reference for institutions aiming to cultivate independent, scientifically competent, and ethically grounded graduates.

Method

Research Design and Approach

This study employs a qualitative research approach with a multiple case study design to investigate the model of internalizing entrepreneurial character among *santri* through an integrated agribusiness framework (Adeyanju, Mburu, Gituro, Chumo, Mignouna, & Mulinganya, 2023; Guo et al., 2024; Nogueira Dias et al., 2025). The qualitative paradigm was selected to enable an in-depth, contextual exploration of how entrepreneurial values are transmitted, practiced, and internalized within the unique socio-religious environment of Islamic boarding schools (*pesantren*). The case study design allows for a holistic examination of the phenomenon within its real-life context, facilitating the identification of patterns, processes, and underlying mechanisms that shape entrepreneurial character development.

Research Setting and Participants

The research was conducted at two purposively selected Islamic boarding schools in East Ogan Komering Ulu (OKU Timur), Indonesia: Pondok Pesantren Nurussalam and Pondok Pesantren Darul Falah. These institutions were chosen based on their established track records in developing agribusiness-based entrepreneurial programs and their commitment to integrating Islamic values with practical economic skills. Participants included *santri* actively involved in agribusiness units, *ustadz/ustadzah* (religious teachers), program coordinators, and pesantren management staff. Purposive and snowball sampling techniques were applied to ensure the inclusion of information-rich cases capable of providing deep insights into the internalization process.

Data Collection Methods

Data were gathered through three primary techniques to ensure triangulation and depth: In-depth Interviews: Semi-structured interviews were conducted with *santri*, educators, and administrators to explore their experiences, perceptions, and reflections regarding the integration of agribusiness practices and entrepreneurial character formation. Interview guides were developed based on the research objectives and refined iteratively during fieldwork; Participatory Observation: The researcher engaged in direct observation of daily agribusiness activities, classroom sessions, extracurricular training, and community engagement events. Field notes were systematically recorded to capture behavioral patterns, interaction dynamics, and contextual nuances that might not emerge through verbal accounts alone; and Document Analysis: Relevant institutional documents—including curricula, program reports, activity logs, policy guidelines, and promotional materials—were reviewed to corroborate interview and observational data and to trace the formal structures supporting entrepreneurial character internalization.

Data Analysis Technique

Data analysis followed an inductive, thematic approach consistent with qualitative inquiry. Transcripts, field notes, and documents were systematically coded using open, axial, and selective coding procedures to identify recurring themes, categories, and relationships. The analysis focused on answering "how" and "why" questions concerning the processes, strategies, challenges, and outcomes of entrepreneurial character internalization. NVivo software assisted in organizing and managing the coding process, while manual interpretation ensured contextual sensitivity and theoretical coherence.

Trustworthiness and Rigor

To ensure credibility, transferability, dependability, and confirmability, several strategies were implemented: Triangulation: Methodological

triangulation (interviews, observation, documents) and source triangulation (multiple participant groups) were employed to cross-validate findings; Member Checking: Preliminary interpretations were shared with key participants to verify accuracy and resonance with their lived experiences; Thick Description: Detailed contextual accounts were provided to enable readers to assess the applicability of findings to similar settings; and Reflexivity: The researcher maintained a reflexive journal to document assumptions, positionalities, and decision-making processes throughout the study.

Result and Discussion

The study identified structured approaches to embedding scientific knowledge into entrepreneurial character internalization at both *pesantren*. Scientific practices were not taught in isolation but operationalized through daily agribusiness activities that required *santri* to apply empirical reasoning, environmental monitoring, and evidence-based management.

Science-Embedded Curriculum and Training

At Pondok Pesantren Nurussalam, *santri* engaged in cyclical agricultural practices grounded in agronomic science, including soil fertility testing, organic compost formulation, integrated pest management, and seasonal crop rotation. Theoretical instruction in plant physiology and microclimate management was directly applied to field production, with mentors guiding students to record yield data, adjust inputs, and evaluate outcomes scientifically (Adeyanju, Mburu, Gituro, Chumo, Mignouna, Mulinganya, et al., 2023; Karimi et al., 2026; Machado et al., 2024). Pondok Pesantren Darul Falah emphasized technology-integrated agriculture, utilizing hydroponic systems, nutrient solution calibration, pH/EC monitoring, and digital inventory tracking. *Santri* were trained to interpret scientific metrics to optimize growth conditions, reduce waste, and forecast market supply, fostering a culture of data-driven entrepreneurship (Adeyanju et al., 2024; Awad, 2023; Ikuemonisan et al., 2022).

Mechanisms of Science-Character Integration

Three interlocking mechanisms facilitated character internalization: (1) *Science-infused mentorship*, where educators explicitly linked experimental rigor, accuracy, and sustainable resource use to Islamic virtues like *amanah* (stewardship) and *ikhlas* (integrity); (2) *Reflective scientific practice*, wherein *santri* documented observations, analyzed production variables, and discussed failures as opportunities for iterative improvement, reinforcing resilience and intellectual humility; and (3) *Community science-engagement*, where students applied scientific agribusiness solutions to lozal farming challenges, positioning innovation as a form of social responsibility (Krova et al., 2025; Widiastuti et al., 2024; Zhou et al., 2026).

Outcomes in Scientific and Entrepreneurial Competency

Qualitative evidence indicated significant growth in *santri*'s scientific reasoning and entrepreneurial self-efficacy (Kovshov et al., 2023; Mambile et al., 2025; Ramaano, 2024). Participants demonstrated increased ability to diagnose crop stressors, calibrate technical inputs, and adapt production models based on environmental feedback. Entrepreneurial behaviors such as cost-benefit analysis, risk mitigation through scientific forecasting, and ethical pricing aligned with sustainable yield emerged organically from their science-based training (Oppong-Kyeremeh et al., 2024; Tarihoran et al., 2023; Zomorrodi et al., 2024). Alumni trajectories further suggested that graduates were more likely to initiate evidence-based agribusiness ventures or adopt sustainable farming practices in their communities, reflecting a durable integration of scientific literacy and entrepreneurial character (Almeida et al., 2025; Ferreras-Garcia et al., 2020; Lopatka, 2021).

The internalization of entrepreneurial character within Islamic boarding schools emerges not as a byproduct of vocational training, but as a deliberate pedagogical synthesis of spiritual formation, applied agricultural science, and experiential learning (Ramoglou et al., 2026; Samenjo, 2025; Vesper et al., 2024). This study demonstrates that when scientific agribusiness practices are systematically aligned with Islamic ethical frameworks, *santri* develop a resilient "santripreneur" identity characterized by dual accountability: to economic viability and spiritual integrity. Rather than treating ethics as a supplementary module, the observed model embeds moral reasoning directly into production cycles, resource management, and market engagement (Kim et al., 2026; Nassar, 2025; Satar et al., 2025). This positions *pesantren* not merely as religious institutions or skill-training centers, but as living laboratories for value-driven economic innovation, challenging the conventional dichotomy between moral education and entrepreneurial competency (Hagerer, 2025; Niva et al., 2026; Portuguez-Castro & Ramírez-Montoya, 2025).

A critical insight from this study lies in the triadic mechanism that enables effective internalization: value-infused mentorship, reflective scientific practice, and community-engaged innovation. Mentorship proves pivotal not as mere knowledge transfer, but as moral scaffolding (Hulyadi et al., 2025; Martínez-Martínez et

al., 2025; Oliver et al., 2025). When *ustadz* and program facilitators explicitly frame risk-taking, resource efficiency, and fair pricing as expressions of Islamic stewardship (*khilafah*) and trustworthiness (*amanah*), entrepreneurial behaviors transition from external requirements to embodied dispositions (Battaglia et al., 2026; Listopadzka et al., 2025; Vitti et al., 2025). Simultaneously, the integration of agricultural science—soil testing, hydroponic calibration, yield forecasting, and data-driven planning—transforms routine farming into applied inquiry (Mannevaara et al., 2024; Rabelo Neto et al., 2024; Tsoutsa et al., 2024). *Santri* learn to diagnose variables, iterate solutions, and treat failure as empirical feedback, fostering intellectual resilience and adaptive innovation. When coupled with structured reflection, these experiences cultivate entrepreneurial self-efficacy grounded in evidence rather than intuition, addressing a persistent gap in informal vocational settings where technical training and character development are often siloed (Bragelien & Nazar, 2026; Franco et al., 2023).

The divergence between the two case sites further underscores a vital principle for scalability: effective internalization frameworks must be context-responsive rather than standardized (Kolajo et al., 2026; Mudjahidin et al., 2024; Vögele, 2025). While one institution emphasized agroecological practices and the other prioritized technology-integrated cultivation, both achieved character internalization by maintaining a consistent pedagogical linkage between scientific practice, economic decision-making, and ethical reflection (Gao, 2026; Hilarowicz et al., 2023; Yi & Park, 2024). This suggests that replication across diverse *pesantren* contexts should prioritize capacity-building in value-based pedagogy and experiential curriculum design over prescriptive technological adoption. Strategic partnerships with agricultural universities, agri-tech enterprises, and local cooperatives can bridge resource constraints while preserving institutional autonomy and spiritual identity (Gonzalez-Tamayo et al., 2025; Kurniasari et al., 2026; Sancho et al., 2026).

The findings carry significant theoretical, practical, and policy implications (Duong et al., 2025; Huang et al., 2026; Žilka et al., 2024). Theoretically, they advance character education and Islamic entrepreneurship literature by demonstrating how moral dispositions are cultivated through structured, science-informed practice rather than didactic instruction (Alshebami et al., 2025; Bastidas et al., 2023; Xiang et al., 2026). Practically, the study offers a replicable framework for *pesantren* leaders to redesign learning ecosystems that harmonize agricultural science, business management, and ethical pedagogy into cohesive daily routines (Bechthold et al., 2022; Lazarte-Aguirre, 2025; Tao, 2026). For policymakers, the results advocate for targeted support in educator upskilling, digital infrastructure, and market linkage programs that formally recognize *pesantren* as legitimate nodes in national agricultural innovation and rural development networks. Overlooking this potential perpetuates an outdated separation between religious education and economic modernization (Alfaifi et al., 2022; Alvarez-Icaza et al., 2025; Karimi et al., 2026).

While this qualitative case study provides rich contextual insights, its findings are bounded by the specific socio-geographic and institutional characteristics of two rural *pesantren*. Future research should employ longitudinal designs to track graduate trajectories, business sustainability, and community economic impact over time (Blanka et al., 2022; Ramírez-Montoya et al., 2024; Sleiman et al., 2025). Comparative studies across urban, coastal, and digitally focused boarding schools would further test the model's transferability. Additionally, developing validated metrics to quantify the "santripreneur" identity construct and its correlation with entrepreneurial performance would strengthen empirical generalizability (Hayter, 2026; Martín-Gutiérrez et al., 2025; Zuo et al., 2025).

Ultimately, the integrated agribusiness model examined here redefines the pedagogical mission of Islamic boarding schools in the contemporary era (Albrecht et al., 2025; Audretsch & Belitski, 2025; Nguyen-Van et al., 2025). By harmonizing scientific literacy, entrepreneurial agility, and Islamic ethics, *pesantren* can cultivate a new generation of leaders who view economic agency not as a departure from spiritual values, but as their practical expression. Strengthening this nexus offers a sustainable pathway toward rural empowerment, food system resilience, and morally grounded economic development, positioning Islamic educational institutions as critical contributors to Indonesia's sustainable development agenda.

Conclusion

This study confirms that integrating agricultural science into entrepreneurial training effectively internalizes entrepreneurial character among *santri*. At Pondok Pesantren Nurussalam and Darul Falah, the deliberate coupling of scientific practices—such as agronomic management, hydroponic technology, data monitoring, and sustainable resource planning—with Islamic ethical principles cultivates a "santripreneur" identity where scientific literacy, economic agency, and spiritual accountability reinforce one another. Character internalization is most robust when grounded in experiential science learning, reflective empirical practice, and value-infused mentorship. Practically, the findings affirm that pesantren can serve as dynamic

incubators for science-driven, values-based entrepreneurship. However, long-term scalability requires addressing systemic constraints through targeted capacity building, technological access, and multi-stakeholder partnerships that bridge religious education, agricultural science, and market ecosystems. Future research should explore longitudinal impacts of science-based santripreneurship on graduate livelihoods, ecological sustainability metrics, and the transferability of this model to urban or digitally focused pesantren. Strengthening the nexus between scientific education, entrepreneurial training, and character formation offers a sustainable pathway toward developing resilient, innovative, and ethically grounded leaders for Indonesia's agricultural and economic future.

Acknowledgments
Thank you to all parties who have helped in this research so that this article can be published.

Author Contributions
All authors contributed to writing this article.

Funding
No external funding.

Conflicts of Interest
No conflict interest.

References

Adeniji, Y. A., Burtnett, S. L., Ibrahim, M. I., & Harvatine, K. J. (2025). Effect of a blend of palmitic and stearic acid on transfer of preformed fatty acids into milk fat using an 18 C n-3 fatty acid perturbation model. *Journal of Dairy Science*, *108*(12), 13302–13312. https://doi.org/10.3168/jds.2025-26838

Adeyanju, D., Mburu, J., Gituro, W., Chumo, C., Mignouna, D., & Mulinganya, N. (2023). Impact of agribusiness empowerment interventions on youth livelihoods: Insight from Africa. *Heliyon*, *9*(11). https://doi.org/10.1016/j.heliyon.2023.e21291

Adeyanju, D., Mburu, J., Gituro, W., Chumo, C., Mignouna, D., & Mulinganya, N. (2024). Harnessing the job creation capacity of young rural agripreneurs: A quasi-experimental study of the ENABLE program in Africa. *Social Sciences and Humanities Open*, *9*. https://doi.org/10.1016/j.ssaho.2023.100791

Adeyanju, D., Mburu, J., Gituro, W., Chumo, C., Mignouna, D., Mulinganya, N., & Ashagidigbi, W. (2023). Can young agripreneurs improve their skills through agripreneurship empowerment programmes? Evidence from Africa. *Heliyon*, *9*(1). https://doi.org/10.1016/j.heliyon.2023.e12876

Albrecht, N., Franzke, S. K., Baum, M., & Isidor, R. (2025). Rebel, reverse, or relent: How female entrepreneurs develop communication strategies on social media to handle gender role stereotypes. *European Management Journal*. https://doi.org/10.1016/j.emj.2025.07.002

Alfaifi, S., Bridges, S., & Arakawa, N. (2022). Developing pharmacists' competencies in Saudi Arabia: A proposed national competency framework to support initial education and professional development. *Currents in Pharmacy Teaching and Learning*, *14*(10), 1256–1268. https://doi.org/10.1016/j.cptl.2022.09.010

Almeida, D. C., Afonso, P., Ferreira, L. P., & Soares, A. M. (2025). Exploring the longitudinal impact of entrepreneurial education on entrepreneurial competences and intentions: evidence of an asymmetric polarization effect. *International Journal of Management Education*, *24*(1). https://doi.org/10.1016/j.ijme.2025.101291

Alshebami, A. S., Fazal, S. A., Amin, M. B., Seraj, A. H. A., Sobaih, A. E. E., & Oláh, J. (2025). Ripple effect of gig work: How hands-on experience and networks shape future female entrepreneurs. *Sustainable Technology and Entrepreneurship*, *5*(1). https://doi.org/10.1016/j.stae.2025.100118

Alvarez-Icaza, I., Miranda, J., Martínez-Arboleda, A., Suárez-Brito, P., & Ramírez-Montoya, M. S. (2025). Driving complex thinking and technological entrepreneurship with artificial intelligence: a mixed methods study. *Sustainable Futures*, *10*. https://doi.org/10.1016/j.sftr.2025.101312

Amoabeng-Nimako, S., Ingenbleek, P. T. M., Dittoh, S., Gouzaye, A., & Bindraban, P. (2025). Designing an incentive system to promote the adoption of sustainable soil health management practices among smallholder farmers in northern Ghana. *Land Use Policy*, *161*. https://doi.org/10.1016/j.landusepol.2025.107847

Audretsch, D. B., & Belitski, M. (2025). Knowledge spillover of innovation: Entrepreneurial difference. *Research Policy*, *55*(1). https://doi.org/10.1016/j.respol.2025.105362

Awad, M. H. (2023). Microfoundations of the waste-to-resource problem in circular economy transitions: Antenarratives of phosphorus in Dutch agribusiness (2008–2014. *Journal of Cleaner Production*, *406*. https://doi.org/10.1016/j.jclepro.2023.136952

Bakas, K., Saddik, A., Dliou, A., Hssaisoune, M., El Hachemy, S., Ait-Ichou, H., El Hafyani, M., Labbaci, A., & Bouchaou, L. (2025). UAV-based citrus tree segmentation, counting and yield estimation using lightweight deep learning

approaches. *Smart Agricultural Technology*, *12*. https://doi.org/10.1016/j.atech.2025.101618

Bastidas, V., Oti-Sarpong, K., Nochta, T., Wan, L., Tang, J., & Schooling, J. (2023). Leadership for responsible digital innovation in the built environment: A socio-technical review for re-establishing competencies. *Journal of Urban Management*, *12*(1), 57–73. https://doi.org/10.1016/j.jum.2023.01.004

Battaglia, D., Colombelli, A., Panelli, A., Paolucci, E., & Raguseo, E. (2026). Entrepreneurs-as-Scientists and entrepreneurial team formation strategies: A randomized control trial experiment. *Research Policy*, *55*(4). https://doi.org/10.1016/j.respol.2026.105461

Bechthold, L., Huber, L. R., & Eddleston, K. A. (2022). Debiasing entrepreneurial careers: A field experiment on female role model effects on entrepreneurial self-efficacy and early-stage career choices. *Journal of Business Venturing*, *41*(3). https://doi.org/10.1016/j.jbusvent.2026.106582

Blanka, C., Krumay, B., & Rueckel, D. (2022). The interplay of digital transformation and employee competency: A design science approach. *Technological Forecasting and Social Change*, *178*. https://doi.org/10.1016/j.techfore.2022.121575

Bragelien, J. J., & Nazar, M. (2026). Entrepreneurial education – An exploration of a project that evaluates a Matchmaking Event in an Internship course. *Procedia Computer Science*, *278*, 1750–1759. https://doi.org/10.1016/j.procs.2026.03.166

Calafat-Marzal, C., Cervera, F. J., García-Mollá, M., & Sanz-Torro, V. (2025). Agricultural dynamism and the influence of territorial characteristics in attracting young farmers. *Journal of Rural Studies*, *121*. https://doi.org/10.1016/j.jrurstud.2025.103896

Carbajal, M., Jones, D., Williams, C., & Nelson, N. G. (2025). In-season yield forecasting using multitemporal remote sensing environmental observations and machine learning: Applications for sweetpotato in North Carolina, USA. *European Journal of Agronomy*, *172*. https://doi.org/10.1016/j.eja.2025.127818

Conte, L., Surra, F., Favarin, S., Comar, V., & Gonella, F. (2025). Systems modeling for agroecology and land restoration. *Ecological Modelling*, *510*. https://doi.org/10.1016/j.ecolmodel.2025.111307

Dohou, M. D., Codjo, O. S., Schreinemachers, P., Totin, E., Amadou, Z., Yabi, J. A., Glin, L. C., & Ba, M. N. (2026). Impact of business coaching on farmers' income: A cluster randomized controlled trial of vegetable growers in Benin. *Food Policy*, *140*. https://doi.org/10.1016/j.foodpol.2026.103081

Duncan, E., Ruder, S. L., KC, K. B., Wittman, H., & Fraser, E. (2026). The political economy of agricultural data governance: Farmer perspectives on trust in data sharing. *Journal of Rural Studies*, *123*. https://doi.org/10.1016/j.jrurstud.2026.104076

Duong, L., Gugenishvili, I., Brännback, M., & Kickul, J. (2025). Gender stereotypes and Gen Z: navigating gender beliefs transfer through entrepreneurial pitching. *International Journal of Entrepreneurial Behaviour and Research*, *31*(11), 293–313. https://doi.org/10.1108/IJEBR-01-2025-0083

Ferreras-Garcia, R., Sales-Zaguirre, J., & Serradell-López, E. (2020). Developing entrepreneurial competencies in higher education: a structural model approach. *Education and Training*, *63*(5), 720–743. https://doi.org/10.1108/ET-09-2020-0257

Franco, L. F. M., Costa, A. C., Almeida Neto, A. F., Moraes, Â. M., Tambourgi, E. B., Miranda, E. A., Castilho, G. J., Doubek, G., Dangelo, J. V. H., Fregolente, L. V, Lona, L. M. F., Torre, L. G., Alvarez, L. A., Costa, M. C., Martinez, P. F. M., Ceriani, R., Zemp, R. J., Vieira, R. P., Maciel Filho, R., & Suppino, R. S. (2023). A competency-based chemical engineering curriculum at the University of Campinas in Brazil. *Education for Chemical Engineers*, *44*, 21–34. https://doi.org/10.1016/j.ece.2023.04.001

Gao, C. (2026). Mismatch in perceptions and knowledge? Prominent entrepreneurial resources through collaborative workspaces for social entrepreneurs. *Journal of Innovation and Knowledge*, *14*. https://doi.org/10.1016/j.jik.2026.100956

Gonzalez-Tamayo, L. A., Maheshwari, G., Krauss-Delorme, C., & Bonomo-Odizzio, A. (2025). Startup decision-making: integrating trial-and-error with the entrepreneur-as-scientist approach. *Journal of Small Business and Enterprise Development*, *32*(8), 169–196. https://doi.org/10.1108/JSBED-03-2025-0165

Guo, Y., Yan, J., & Zhuang, P. (2024). How does data sharing affect the sustainable development of agribusiness? Evidence from public data openness. *International Review of Economics and Finance*, *97*. https://doi.org/10.1016/j.iref.2024.103785

Hagerer, I. (2025). PlayMINT—an effective digital learning game for leadership competencies of female STEM students. *Computers and Education Open*, *8*. https://doi.org/10.1016/j.caeo.2025.100256

Hayter, C. S. (2026). Bringing "her" to life: Why entrepreneurial teams anthropomorphize their focal technologies under uncertainty. *Journal of Business Venturing Insights*, *25*.

https://doi.org/10.1016/j.jbvi.2026.e00597

Hilarowicz, A., Zielosko, B., & Mysliwiec, M. (2023). The Employers' Expectations Towards Students' Competencies In The Framework Of Digital Transformation Processes. *Procedia Computer Science*, *225*, 4521–4530. https://doi.org/10.1016/j.procs.2023.10.450

Houser, M., Fisher, K. A., Fife, A., Bunn, A., & McHenry, J. (2026). Evaluating conservation incentive programs: Piloting a novel approach to enabling farmer behavior change. *Journal of Rural Studies*, *124*, 104192. https://doi.org/10.1016/j.jrurstud.2026.104192

Huang, Y., He, R., Wu, K., He, D., & Xie, J. (2026). Multiple pathways to generative AI entrepreneurial behavior: A mixed-methods study of Chinese undergraduates. *International Journal of Management Education*, *24*(2). https://doi.org/10.1016/j.ijme.2026.101373

Hulyadi, S., Azmi, I., Prayogi, S., & Verawati, N. N. S. P. (2025). Project-based teaching factory in the chemical cleaning industry to enhance students' soft skills and entrepreneurial intention. *Social Sciences and Humanities Open*, *12*. https://doi.org/10.1016/j.ssaho.2025.102221

Ikuemonisan, E. S., Abass, A. B., Feleke, S., & Ajibefun, I. (2022). Influence of Agricultural Degree Programme environment on career in agribusiness among college students in Nigeria. *Journal of Agriculture and Food Research*, *7*. https://doi.org/10.1016/j.jafr.2021.100256

Jin, H., Li, M., Hopwood, G., Hochman, Z., & Bakar, K. S. (2022). Improving early-season wheat yield forecasts driven by probabilistic seasonal climate forecasts. *Agricultural and Forest Meteorology*, *315*. https://doi.org/10.1016/j.agrformet.2022.108832

Karimi, S., Mohammadi, F., & Farani, A. Y. (2026). Corporate Social Responsibility and Green Dynamic Capabilities as Drivers of Environmental Performance in Volatile Contexts. *Cleaner Environmental Systems*, *100396*. https://doi.org/10.1016/j.cesys.2026.100396

Kim, L., Rakangthong, N. K., Lak, C., & Aujirapongpan, S. (2026). A Competency Mechanism for Customer Trust Enhancement in Digital Banking Services. *Journal of Open Innovation: Technology, Market, and Complexity*, *100752*. https://doi.org/10.1016/j.joitmc.2026.100752

Kolajo, B. F., Laosebikan, J. O., & Smith, R. F. (2026). Bridging the gap between education and employability: A transformative entrepreneurship curriculum model for Nigerian secondary schools. *Scientific African*, *32*. https://doi.org/10.1016/j.sciaf.2026.e03353

Kovshov, V., Lukyanova, M., Zalilova, Z., Frolova, O., & Galin, Z. (2023). International regional competitiveness of rural territories as a factor of their socio-economic development: Methodological aspects. *Heliyon*, *10*(1). https://doi.org/10.1016/j.heliyon.2023.e23795

Krova, M., Saptati, R. A., Hutapea, R. T. P., Pribadi, E. R., Sabat, D. M., Sol'Uf, M. M., Saptana, M., P., I. G. A., Kindangen, J. G., Sondakh, J. O. M., & Silva, H. (2025). Comparative study of factors supporting broiler business development in Indonesian Border Areas with various characteristics: Structural Equation modeling using Partial Least Squares (SEMPLS. *Social Sciences and Humanities Open*, *12*. https://doi.org/10.1016/j.ssaho.2025.102170

Kurniasari, F., Lestari, E. D., Muslim, N. A., & Mohd Ali, M. A. (2026). From knowledge to prosperity: Financial literacy driving women entrepreneur led-small medium enterprises through technology innovation. *Social Sciences and Humanities Open*, *13*. https://doi.org/10.1016/j.ssaho.2026.102443

Lazarte-Aguirre, A. (2025). Entrepreneurial traits and sustainable entrepreneurial orientation in Peru: A PLS-SEM analysis of micro and small-sized enterprises. *Sustainable Futures*, *10*. https://doi.org/10.1016/j.sftr.2025.101101

Listopadzka, E., Dunajko, I. K., & Prokopowicz, D. (2025). Teachers as Architects of Green Readiness: Future-Ready Competencies in Education. *Procedia Computer Science*, *270*, 928–936. https://doi.org/10.1016/j.procs.2025.09.213

Lopatka, A. (2021). Entrepreneurial competencies of women ICT start-up. *Procedia Computer Science*, *192*, 5122–5129. https://doi.org/10.1016/j.procs.2021.09.290

Machado, R. B., Aguiar, L. M., & Bustamante, M. M. (2024). Why is it so easy to undergo devegetation in the Brazilian Cerrado? *Perspectives in Ecology and Conservation*, *22*(3), 209–212. https://doi.org/10.1016/j.pecon.2024.08.003

Mambile, C., Mwangakala, H. A., Chali, F., Julius, B., Shao, D., Mongi, H., & Ishengoma, F. (2025). Evaluating blockchain technology for contract farming in tanzania: A task-technology fit analysis. *Sustainable Futures*, *10*. https://doi.org/10.1016/j.sftr.2025.100905

Mannevaara, P., Kinnunen, U. M., Egbert, N., Hübner, U., Vieira-Marques, P., Sousa, P., & Saranto, K. (2024). Discovering the importance of health informatics education competencies in healthcare practice. A focus group interview. *International Journal of Medical Informatics*, *187*. https://doi.org/10.1016/j.ijmedinf.2024.105463

Martín-Gutiérrez, Á., Fernández-Salinero Miguel, C., García-Mora, M. E., & Montero-Pedrera, A. M. (2025). Effectiveness of the PEIEO program to develop the entrepreneurial potential of Spanish students in Secondary Education and Vocational Training. *Social Sciences and Humanities Open*, *11*. https://doi.org/10.1016/j.ssaho.2025.101365

Martínez-Martínez, S. L., Ventura, R., & Santos-Jaén, J. M. (2025). Creativity Vs Grit: key competences to understand Entrepreneurial Intention. *International Journal of Management Education*, *23*(2). https://doi.org/10.1016/j.ijme.2025.101143

Melo, G. A., Castro Júnior, L. G., Mendonça Peixoto, M. G., Barbosa, S. B., Costa, J. S., Angélico Mendonça, M. C., Marques Serrano, A. L., & Gomes Ferreira, L. O. (2026). Performance management in coffee growing: A multivariate analysis applied to coffee production in the main Brazilian regions. *Computers and Electronics in Agriculture*, *245*. https://doi.org/10.1016/j.compag.2026.111500

Modica, F., Sgroi, F., Totaro, T., & Sciortino, C. (2025). Which are the main drivers that affected the consumers' WTP for tropical fruits? A logistic model approach for quality certification and Sicily origin. *Food and Humanity*, *5*. https://doi.org/10.1016/j.foohum.2025.100704

Mudjahidin, M., Aristio, A. P., Balbeid, N. H., & Junaedi, L. (2024). The Influence of Social Media Sales Intensity and Competency on the Improvement of Business Performance Satisfaction in MSMEs. *Procedia Computer Science*, *234*, 869–875. https://doi.org/10.1016/j.procs.2024.03.074

Nassar, F. S. (2025). Strategic soft power for developing poultry production competencies and empowering the next generation of industry professionals. *Poultry Science*, *104*(11). https://doi.org/10.1016/j.psj.2025.105805

Ngarava, S. (2026). Innovation heterogeneity and resilience pathways in South African Agri-businesses. *Agricultural Systems*, *235*. https://doi.org/10.1016/j.agsy.2026.104720

Nguyen-Van, H., Le, A. H., Nguyen, C., Ho, L. D., & Nguyen, Q. T. T. (2025). Green ambidextrous innovation and sustainable performance in Vietnam's low-carbon transition: The role of green intellectual capital, green ambidextrous leadership, and green entrepreneurial orientation. *Journal of Open Innovation: Technology, Market, and Complexity*, *11*(4). https://doi.org/10.1016/j.joitmc.2025.100655

Niva, A., Markkula, J., & Annanperä, E. (2026). Software engineering competency models and intercultural communication competencies: A systematic literature review. *Journal of Systems and Software*, *232*. https://doi.org/10.1016/j.jss.2025.112662

Nogueira Dias, C., Martínez-Fernández, T., & Hoffmann, V. E. (2025). Building technologies to market: Can network structure and resources explain innovation in agribusiness? *Journal of Engineering and Technology Management - JET-M*, *76*. https://doi.org/10.1016/j.jengtecman.2025.101878

Oliver, P. G., Mora, L., & Zhang, J. (2025). Collaboration before competition: How smart city entrepreneurs co-create temporary ecosystems to build capacity for learning. *Technological Forecasting and Social Change*, *214*. https://doi.org/10.1016/j.techfore.2025.124046

Olivera, L. C., Mendonça, G. C., Araújo Costa, R. C., Camargo, R. A., Fernandes, L. F. S., Pacheco, F. A. L., & Pissarra, T. C. T. (2022). Impacts of urban sprawl in the Administrative Region of Ribeirão Preto (Brazil) and measures to restore improved landscapes. *Land Use Policy*, *124*. https://doi.org/10.1016/j.landusepol.2022.106439

Oppong-Kyeremeh, H., Bannor, R. K., & Mensah, J. O. (2024). Branding locally produced chicken in Ghana: An application of discrete choice experiment. *Heliyon*, *10*(22). https://doi.org/10.1016/j.heliyon.2024.e40208

Portuguez-Castro, M., & Ramírez-Montoya, M. S. (2025). Transformative economies and complex Thinking: Enhancing sustainability competencies in business education. *International Journal of Management Education*, *23*(3). https://doi.org/10.1016/j.ijme.2025.101223

Prioli Duarte, D., Peres, C. A., Perdomo, E. F. C., Guizar-Coutiño, A., & Nelson, B. W. (2023). Reducing natural vegetation loss in Amazonia critically depends on the formal recognition of indigenous lands. *Biological Conservation*, *279*. https://doi.org/10.1016/j.biocon.2023.109936

Rabelo Neto, J. d. S., Coelho, B. F. C., Valente, R., & Figueiredo, C. R. C. (2024). Metrics and indicators in assessing innovation and entrepreneurial ecosystems: a comparative analysis of GII and GEM. *Journal of Science and Technology Policy Management*, *17*(11), 1–25. https://doi.org/10.1108/JSTPM-06-2024-0225

Ramaano, A. I. (2024). Rural pursuits and local climate change influence on subsistence: a sustainable tourism approach to provincial environmental governance and sustainability targets. *Management of Environmental Quality*, *37*(1), 208–233. https://doi.org/10.1108/MEQ-07-2024-0303

Ramírez-Montoya, M. S., Casillas-Muñoz, F., Tariq, R., Álvarez-Icaza, I., & Portuguez-Castro, M. (2024). Reimagining the future through the co-creation of

social entrepreneurship in higher education: a multivariate prediction model approach. *Kybernetes*, *54*(16), 1–19. https://doi.org/10.1108/K-07-2024-1924

Ramoglou, S., Shang, L., Chandra, Y., & McMullen, J. S. (2026). Are language models intelligent enough for entrepreneurial work? A language-centered perspective. *Journal of Business Venturing*, *41*(3). https://doi.org/10.1016/j.jbusvent.2026.106589

Ramos Collin, B. R., Lima Alves Xavier, D., Amaral, T. M., Castro Silva, A. C. G., Santos Costa, D., Amaral, F. M., & Oliva, J. T. (2024). Random forest regressor applied in prediction of percentages of calibers in mango production. *Information Processing in Agriculture*, *12*(3), 370–383. https://doi.org/10.1016/j.inpa.2024.12.002

Romani, L. A. S., Evangelista, S. R. M., Vacari, I., Apolinário, D. R. F., Vaz, G. J., Speranza, E. A., Barbosa, L. A. F., Drucker, D. P., & Massruhá, S. M. F. S. (2023). AgroAPI platform: An initiative to support digital solutions for agribusiness ecosystems. *Smart Agricultural Technology*, *5*. https://doi.org/10.1016/j.atech.2023.100247

Samenjo, K. T. (2025). Realizing Accessible and Environmentally Sustainable Medical Devices in Low-Resource Healthcare Settings in Sub-Saharan Africa: Personal Narrative of the Designer's Roles and Competencies. *She Ji*, *11*(1), 99–122. https://doi.org/10.1016/j.sheji.2025.01.005

Sancho, M. P. L., Martín-Hidalgo, F. A., & Ramos Rodríguez, A. R. (2026). University business creation courses: Bibliometric insights and challenges for transformative entrepreneurship education. *International Journal of Management Education*, *24*(2). https://doi.org/10.1016/j.ijme.2026.101370

Satar, D. M. S., Alarifi, G., & Alhawsawi, M. S. (2025). Digitalization and non-profits: Competency requirements in non-profit sector of Saudi Arabia. *Sustainable Technology and Entrepreneurship*, *4*(1). https://doi.org/10.1016/j.stae.2024.100083

Shen, H., Dai, X., Liu, C., & Li, H. (2026). Analysis of agro-product trade research characteristics under global uncertainty: based on BERTopic model. *Journal of Integrative Agriculture*. https://doi.org/10.1016/j.jia.2026.04.002

Sleiman, K. A. A., Abushanab, E., Ali, M. S. Y., Suliman, M. A. E., & Juanli, L. (2025). Understanding the determinants of entrepreneurial intention among Sudanese university students. *Acta Psychologica*, *262*. https://doi.org/10.1016/j.actpsy.2025.106122

Tanaka, J., Scuderi, A., & Privitera, D. (2025). Why Landless Workers' Movement wants more than farmers' markets: the scaling up of agroecology and social justice in Brazil. *Journal of Rural Studies*, *122*. https://doi.org/10.1016/j.jrurstud.2025.103956

Tao, Z. (2026). How environmental corporate social responsibility affects green product innovation in China high-pollution industry: The mediating role of green entrepreneurial orientation. *Innovation and Green Development*, *5*(1). https://doi.org/10.1016/j.igd.2026.100330

Tarihoran, A. D. B., Hubeis, M., Jahroh, S., & Zulbainarni, N. (2023). Market-based dynamic capabilities for MSMEs: Evidence from Indonesia's ornamental fish industry. *Journal of Open Innovation: Technology, Market, and Complexity*, *9*(3). https://doi.org/10.1016/j.joitmc.2023.100123

Tsoutsa, P., Panagiotakopoulos, T., Damasiotis, V., & Fitsilis, P. (2024). Empowering urban futures: Key competencies for smart city resilience officers. *Urban Governance*, *4*(3), 180–192. https://doi.org/10.1016/j.ugj.2024.07.001

Uyar, H., Karvelas, I., Rizou, S., & Fountas, S. (2024). Data value creation in agriculture: A review. *Computers and Electronics in Agriculture*, *227*. https://doi.org/10.1016/j.compag.2024.109602

Vesper, D., König, C. J., & Bajwa, N. u. H. (2024). How to become a knowledge entrepreneur: development and validation of training. *Higher Education, Skills and Work-Based Learning*, *15*(7), 186–198. https://doi.org/10.1108/HESWBL-09-2024-0283

Vitti, M., Trevisan, A. H., Ocampo, H. R., Cuentas, V. K., Sarbazvatan, S., Terzi, S., & Sassanelli, C. (2025). A competency map for circular economy education. *Procedia Computer Science*, *253*, 336–345. https://doi.org/10.1016/j.procs.2025.01.096

Vögele, J. (2025). Shaping futures wisely: Integrating futures literacy with entrepreneurship. *Futures*, *175*. https://doi.org/10.1016/j.futures.2025.103732

Widiastuti, D. P., Hatta, M., Aziz, H., Permana, D., Santari, P. T., Rohaeni, E. S., Ahmad, S. N., Bakrie, B., Tan, S. S., & Rakhmani, S. I. W. (2024). Peatlands management for sustainable use on the integration of maize and cattle in a circular agriculture system in West Kalimantan, Indonesia. *Heliyon*, *10*(10). https://doi.org/10.1016/j.heliyon.2024.e31259

Xiang, Z., Xue, X., Yin, Q., Wang, X., & Liu, Z. (2026). Can financial literacy promote rural entrepreneurial resilience? Exploring the asymmetric role of formal and informal credit in China. *International Review of Economics and Finance*, *107*. https://doi.org/10.1016/j.iref.2026.105065

Yi, E., & Park, D. H. (2024). The effect of core competencies of university students on employment and first year salary level based on

school activity log. *Heliyon*, *10*(7). https://doi.org/10.1016/j.heliyon.2024.e28474

Zhang, H., Kuhn, L., Xiong, H., & Sun, Z. (2025). Farmers' preferences for agricultural drone services under uncertainty: A Choice Experiment in Hubei, China. *Journal of Integrative Agriculture*. https://doi.org/10.1016/j.jia.2025.12.066

Zhou, Y., He, W., Tang, H., & Liu, Y. (2026). From complexity to strength: How digital transformation and innovation enhances agricultural supply chain resilience? *Journal of Innovation and Knowledge*, *15*. https://doi.org/10.1016/j.jik.2026.100985

Žilka, M., Kalender, Z. T., Lhota, J., Kalina, V., & Pinto, R. (2024). Tools to support managerial decision - building competencies in data driven decision making in manufacturing SMEs. *Procedia Computer Science*, *232*, 416–425. https://doi.org/10.1016/j.procs.2024.01.041

Zomorrodi, M., Fayezi, S., & Bals, L. (2024). Base of the chain (BoC) sourcing challenges: The role of institutional voids and social agency problems. *Journal of Purchasing and Supply Management*, *30*(5). https://doi.org/10.1016/j.pursup.2024.100953

Zuo, H., Zhang, M., & Huang, W. (2025). Lifelong learning in vocational education: A game-theoretical exploration of innovation, entrepreneurial spirit, and strategic challenges. *Journal of Innovation & Knowledge*, *10*(3), 100694. https://doi.org/10.1016/j.jik.2025.100694