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Innovation Ecosystems for Teaching Factory Agribusiness: A Strategic Framework

Ekosistem Inovasi untuk Teaching Factory Agribisnis: Sebuah Kerangka Strategis

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ABSTRACT

This study investigates innovation ecosystems within Teaching Factory Agribusiness, addressing the critical gap in the literature regarding the absence of a strategic framework to enhance innovation and sustainability in agribusiness education. Using a grounded theory methodology, we conducted in-depth interviews with 20–30 participants, including educators, industry stakeholders, and policymakers, to gain insights into collaboration, resource sharing, and continuous learning dynamics. The results clarify four thematic areas; (1) Collaboration and Partnerships, (2) Resource Mobilization and Sharing, (3) Policy and Institutional Support, and (4) Continuous Learning and Adaptation. The above threads weave together into a framework to make agribusiness education explicit in the functioning of innovation ecosystems. The findings have significance for policy-makers, educationists, and industry personnel involved in improving the quality of agribusiness innovation. Future research directions can be a framework, especially regarding the benefits of innovation, and collaboration through technological facilities.

ABSTRAK

Studi ini menyelidiki ekosistem inovasi dalam Teaching Factory Agribisnis, mengatasi kesenjangan kritis dalam literatur mengenai tidak adanya kerangka kerja strategis untuk meningkatkan inovasi dan keberlanjutan dalam pendidikan agribisnis. Dengan menggunakan metodologi teori yang membumi, kami melakukan wawancara mendalam dengan 20-30 peserta, termasuk pendidik, pemangku kepentingan industri, dan pembuat kebijakan, untuk mendapatkan wawasan tentang kolaborasi, berbagi sumber daya, dan dinamika pembelajaran berkelanjutan. Hasilnya mengklarifikasi empat bidang tematik; (1) Kolaborasi dan Kemitraan, (2) Mobilisasi dan Berbagi Sumber Daya, (3) Dukungan Kebijakan dan Kelembagaan, dan (4) Pembelajaran dan Adaptasi Berkelanjutan. Benang merah di atas terjalin menjadi kerangka kerja untuk membuat pendidikan agribisnis secara eksplisit dalam fungsi ekosistem inovasi. Temuan ini memiliki arti penting bagi pembuat kebijakan, pendidik, dan tenaga industri yang terlibat dalam peningkatan kualitas inovasi agribisnis. Arah penelitian masa depan dapat menjadi kerangka kerja, terutama mengenai manfaat inovasi, dan kolaborasi melalui fasilitas teknologi.

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Introduction

However, over the last few years, the link between education and industry has gotten more focus as both sectors seek to address the issues brought about by both the fast pace of technological changes and the needs of the economy. A specific model is the Teaching Factory, which offers a type of learning environment that allows students to conduct real-world production operations within university settings by simulating the operation of an industry. This is especially relevant for the agribusiness sector as global crises in climate, food security, and technology disruption have raised the urgency for the sector to produce food more sustainably and efficiently through the supply chain (Zhu et al., 2021).

Agribusiness is often considered a sector that takes longer to adapt to technological breakthroughs (Dawson Jr et al., 2024). However, with increasing food demand and a rapidly growing global population-expected to reach 9.7 billion by 2050. There is an urgent need for innovation to increase productivity, minimize environmental impacts, and improve supply chain resilience (FAO, 2017). In this process, educational institutions play an important role and are responsible for preparing the next generation of professionals with the skills needed to lead and implement these innovations (Rastorgueva et al., 2023).

The Teaching Factory concept, while effective at bridging the gap between theoretical learning and practical application, has yet to be fully integrated into the innovation ecosystem that fosters sustained technological advancement. Moreover, research suggests that the success of innovation ecosystems in sectors like agribusiness depends on a strategic framework that facilitates collaboration among diverse stakeholders, including universities, industries, government bodies, and local communities (Chesbrough, 2020). Despite the growing interest in innovation ecosystems, there is still a lack of a formalized strategic framework to guide the development and implementation of these ecosystems within Teaching Factory Agribusiness contexts.

The agribusiness sector faces unique challenges that distinguish it from other industries. Agricultural production is subject to external variables such as climate conditions, soil quality, and water availability. Additionally, the sector is heavily regulated, with policies and subsidies often influencing market dynamics (de Boon et al., 2022). In this complex environment, innovation is not only driven by the need to improve efficiency but also by the necessity to ensure sustainability and adapt to changing regulatory landscapes.

Despite these challenges, there has been a marked increase in the adoption of digital technologies in agribusiness, such as precision agriculture, Internet of Things (IoT)-enabled monitoring systems, and data analytics platforms (Kamilaris et al., 2017). However, the pace of adoption is uneven, with smaller agribusinesses often lacking access to the necessary resources and infrastructure to benefit from these innovations. This presents a significant opportunity for educational institutions to play a pivotal role in fostering innovation ecosystems that are inclusive and supportive of all stakeholders, especially those at the grassroots level (Basso & Antle, 2020).

Educational institutions have the potential to act as innovation hubs by providing a collaborative space where students, researchers, and industry professionals can co-create solutions to the pressing challenges facing the agribusiness sector. This is where the Teaching Factory model can be particularly impactful. However, for this model to reach its full potential, it needs to be embedded within a broader strategic framework that promotes innovation, facilitates resource sharing, and fosters partnerships across the agribusiness value chain (Sultana & Turkina, 2023).

Although there is a growing body of literature on innovation ecosystems in other sectors, such as manufacturing and high-tech industries (Granstrand & Holgersson, 2020). The agribusiness sector remains underexplored. Existing studies have predominantly focused on the economic and operational challenges of agribusiness rather than on the innovation ecosystem as a whole (Rukarwa et al., 2018). Moreover, the concept of Teaching Factories has gained traction in sectors like automotive and aerospace engineering (Klaassen et al., 2024). Its application in agribusiness education is still in its infancy.

Given the growing importance of innovation for the future of agribusiness, this research aims to address the gap by developing a strategic framework tailored to the unique needs of Teaching Factory Agribusiness. This framework will draw on insights from grounded theory and in-depth interviews with key stakeholders across the agribusiness value chain, including educators, policymakers, industry leaders, and students. By doing so, this study seeks to contribute to the literature by offering a comprehensive strategy for building a robust innovation ecosystem within the Teaching Factory model.

The primary objective of this study is to develop a strategic framework that facilitates the creation and sustainability of innovation ecosystems within the Teaching Factory Agribusiness

model. Specifically, the research will focus on the following: Identifying the key components of a successful innovation ecosystem in agribusiness education; Exploring the role of collaboration between universities, industry, and government in fostering innovation; Analyzing the challenges and opportunities associated with integrating innovation ecosystems into the Teaching Factory model; and Proposing actionable strategies that stakeholders can implement to enhance the performance and sustainability of agribusiness education through innovation. By achieving these objectives, the study aims to provide practical recommendations for educational institutions and industry players seeking to leverage the Teaching Factory model as a catalyst for innovation in agribusiness.

Literature Review

Innovation Ecosystem: a Theoretical Perspective

The concept of innovation ecosystems has evolved as a strategic approach to fostering collaboration, co-creation, and resource sharing among different actors, including universities, industries, governments, and other stakeholders. According to Adner (2017), an innovation ecosystem is a network of interconnected organizations, whose interactions help shape the creation and diffusion of new technologies and processes. This view aligns with Moore's (1996) foundational work, which emphasized the importance of ecosystem participants working in synergy to enhance innovation performance.

Within agribusiness, innovation ecosystems are particularly vital due to the sector's reliance on advancements in biotechnology, data-driven farming techniques, and supply chain optimization (Kamilaris et al., 2017). However, the formation of such ecosystems in agribusiness is often hampered by the fragmented nature of the industry, where smallholder farmers, large agribusiness corporations, policymakers, and educational institutions operate in silos. As outlined by Basso & Antle (2020), the digital transformation of agriculture has created opportunities for collaborative innovation, but challenges such as limited access to technology, knowledge disparities, and regulatory constraints hinder the development of robust innovation ecosystems.

The role of innovation ecosystems in sectors like manufacturing and technology has been extensively studied, with research highlighting the importance of institutional support, policy frameworks, and market incentives in driving innovation (Granstrand & Holgersson, 2020). In contrast, the agribusiness sector presents unique challenges that require a tailored approach. According to Chesbrough (2020), open innovation and ecosystem collaboration are critical for industries where rapid technological change is essential for competitiveness, a scenario that increasingly applies to modern agribusiness.

Agribusiness and the Need for Innovation Ecosystems

Agribusiness has traditionally been characterized by incremental innovation, driven by the need for efficiency and sustainability in the face of growing global demand for food (FAO, 2017). However, recent shifts in consumer preferences, environmental regulations, and global supply chain disruptions have accelerated the demand for more transformative innovations (de Boon et al., 2022). These innovations include precision agriculture, which utilizes IoT devices, data analytics, and automation to optimize farming practices (Kamilaris et al., 2017). In this context, the development of innovation ecosystems is crucial for connecting farmers, technologists, researchers, and policymakers to foster innovation and ensure that it is scalable and sustainable.

Despite these opportunities, many agribusiness ecosystems face challenges in mobilizing the necessary resources and expertise to build strong innovation networks. As noted by Rukarwa et al. (2018), the agribusiness sector, particularly in emerging economies, often struggles with low levels of digital literacy and limited access to cutting-edge technologies, which hampers the sector's ability to fully leverage innovation ecosystems. This underscores the importance of creating educational platforms like Teaching Factories that can serve as hubs for innovation and knowledge transfer, enabling agribusiness stakeholders to co-develop solutions that address sector-specific challenges (Rastorgueva et al., 2023).

Teaching Factories: Bridging Education and Industry in Agribusiness

The Teaching Factory model, originally developed in industrial sectors such as automotive and aerospace engineering, integrates real-world production environments into academic curricula. This model allows students to gain hands-on experience and apply theoretical knowledge in practice, while also fostering innovation through collaboration with industry partners (Klaassen et al., 2024). In agribusiness, the Teaching Factory has the potential to address the gap between education and industry by providing students, educators, and industry professionals with opportunities to co-create innovations that meet the specific needs of the sector (Wulandari et al., 2022).

However, while the Teaching Factory concept has been successfully implemented in engineering and manufacturing

education, its application in agribusiness is still relatively new. Research indicates that agribusiness Teaching Factories face several challenges, including the integration of diverse stakeholders, access to technological resources, and alignment of educational outcomes with industry needs (Sultana & Turkina, 2023). These challenges highlight the need for a strategic framework that can guide the development of innovation ecosystems within agribusiness Teaching Factories, ensuring that they contribute not only to educational objectives but also to the advancement of the agribusiness sector as a whole (Dawson Jr et al., 2024).

The role of Teaching Factories in promoting innovation in agribusiness lies in their ability to act as incubators for new ideas, where students, researchers, and industry professionals collaborate on projects that address real-world challenges. According to Klaassen et al. (2024), Teaching Factories offer an environment where innovation can be nurtured through experimental learning, industry engagement, and resource sharing. This aligns with Chesbrough's (2020), view on open innovation, where cross-boundary collaboration is essential for generating new ideas and accelerating technological development.

Strategic Frameworks for Building Innovation Ecosystems in Agribusiness Teaching Factories

Developing a strategic framework for innovation ecosystems within agribusiness Teaching Factories requires a multi-faceted approach that addresses the unique needs of the sector. As highlighted by Granstrand & Holgersson (2020), successful innovation ecosystems depend on several key factors: stakeholder engagement, resource allocation, policy support, and continuous learning. These components must be tailored to the specific dynamics of the agribusiness sector, where innovation is often driven by external pressures such as climate change, regulatory demands, and shifting consumer preferences (Zhu et al., 2021).

Stakeholder engagement is a critical aspect of building innovation ecosystems. In the agribusiness context, this involves fostering collaboration among universities, industry partners, government bodies, and local communities (Gutiérrez Cano et al., 2023). As argued by Sultana & Turkina (2023), engaging stakeholders across the agribusiness value chain is essential for ensuring that innovations are not only technologically feasible but also socially and economically sustainable. In this regard, Teaching Factories can serve as platforms for bringing together diverse actors to co-develop solutions that address the sector's most pressing challenges.

Another key component of the strategic framework is resource sharing and infrastructure development. The success of innovation ecosystems in other sectors, such as manufacturing, has been linked to the availability of shared resources, including technological infrastructure, funding, and expertise (Chesbrough, 2020). In agribusiness, however, resource constraints are a significant barrier to innovation, particularly for small-scale farmers and rural communities (Rastorgueva et al., 2023). Teaching Factories can play a crucial role in addressing this challenge by providing access to cutting-edge technologies, research facilities, and industry expertise.

Finally, continuous learning and knowledge exchange are essential for sustaining innovation ecosystems over time. As noted by Zhu et al. (2021), the rapid pace of technological change in agribusiness necessitates ongoing education and training to ensure that industry professionals and future leaders are equipped with the skills needed to implement and scale innovations. Teaching Factories can facilitate this process by offering educational programs that are aligned with the latest industry trends and technologies, while also fostering a culture of experimentation and collaboration (Klaassen et al., 2024).

Gaps in the Literature

Despite the growing recognition of the importance of innovation ecosystems in agribusiness, there is still a lack of comprehensive studies that address the specific challenges and opportunities associated with the Teaching Factory model in this sector (Wulandari et al., 2022). Most existing research on innovation ecosystems focuses on high-tech industries, where the dynamics of innovation are significantly different from those in agribusiness (Adner, 2017; Granstrand & Holgersson, 2020). This paper aims to fill this gap by developing a strategic framework that is tailored to the unique needs of agribusiness Teaching Factories, offering practical recommendations for fostering innovation in this critical sector.

Methodology

Research Design

This study adopts a qualitative research design rooted in grounded theory, which is particularly well-suited for exploring complex social phenomena where theoretical frameworks are underdeveloped (Charmaz, 2006; Glaser & Strauss, 2017). Grounded theory allows for the generation of theory from data, making it an ideal approach for investigating the development of innovation ecosystems in Teaching Factory Agribusiness—a topic

where existing theoretical frameworks are sparse, particularly in the context of agribusiness education (Sultana & Turkina, 2023). The goal of this research is to generate a strategic framework that can be applied to guide the creation and sustainability of innovation ecosystems within the Teaching Factory model.

Grounded theory is appropriate here because it provides a systematic methodology for collecting and analyzing qualitative data to identify patterns, relationships, and emerging themes (Corbin & Strauss, 2014). The iterative nature of grounded theory—where data collection and analysis occur concurrently—enables the researcher to adapt the research process as new insights emerge, allowing for a more nuanced understanding of the innovation ecosystem in the agribusiness context.

Data Collection

To develop a comprehensive strategic framework for innovation ecosystems within Teaching Factory Agribusiness, this study employs in-depth, semi-structured interviews with key stakeholders involved in the agribusiness ecosystem. The use of semi-structured interviews allows for flexibility in the questioning, enabling the researcher to explore various dimensions of the participants' experiences while ensuring that core topics related to innovation ecosystems and the Teaching Factory model are covered (Brinkmann & Kvale, 2014).

Sample Selection

The research adopts a purposive sampling strategy, selecting participants who have direct experience or involvement in agribusiness innovation, education, and policy-making. Given the complex nature of innovation ecosystems, it is essential to include a wide range of perspectives to capture the interactions and dynamics between various actors (Clark et al., 2021). The sample includes representatives from the following categories: Educational institutions: Professors, administrators, and researchers involved in Teaching Factories and agribusiness education; Industry partners: Executives and managers from agribusiness companies that collaborate with educational institutions or are involved in innovation projects; Policymakers: Government officials or representatives from regulatory bodies who influence policies related to agribusiness and education; Local communities and farmers: Representatives from grassroots agribusiness initiatives and local communities engaged in or impacted by agribusiness innovation ecosystems.

This diverse sample ensures that the research captures a holistic view of the innovation ecosystem, considering the varied roles and interests of different stakeholders (Gutiérrez Cano et al., 2023). The final sample size is expected to consist of 20–30 interviews, which is sufficient to achieve theoretical saturation—a point at which additional data no longer generates new insights (Glaser & Strauss, 2017).

Interview Protocol

The interview protocol is designed to elicit detailed information about the participants' experiences, challenges, and perceptions regarding the role of innovation ecosystems in Teaching Factory Agribusiness. The interview questions are guided by the following themes: Innovation ecosystems: Participants' understanding of innovation ecosystems and their role in agribusiness education; Collaboration and partnerships: How universities, industries, and government agencies collaborate to foster innovation in agribusiness; Challenges and barriers: The obstacles faced in building and sustaining innovation ecosystems in the Teaching Factory context; Strategic frameworks: Participants' views on the key components of a successful innovation ecosystem and potential strategies for enhancing the performance and sustainability of these ecosystems; and Questions are open-ended to encourage participants to share their experiences in their own words, while also allowing the researcher to probe for deeper insights or clarify responses (Patton, 2014).

Data Analysis

Data analysis follows the grounded theory methodology outlined by Corbin & Strauss (2014), which involves three stages of coding: open coding, axial coding, and selective coding. This systematic process enables the researcher to identify emerging themes and relationships in the data, ultimately developing a strategic framework for innovation ecosystems.

Open Coding: In this initial phase, the interview data is broken down into discrete parts and closely examined to identify key concepts and patterns. This involves assigning codes to significant words, phrases, or sentences that relate to innovation ecosystems, Teaching Factories, collaboration, and challenges in agribusiness (Charmaz, 2006). The coding is data-driven and inductive, meaning that it emerges directly from the interview transcripts rather than being predetermined by existing theory.

Axial Coding: Once key concepts have been identified, axial coding is used to explore relationships between these concepts. The researcher groups the open codes into broader categories based on their connections and develops a more coherent understanding of how different aspects of the innovation ecosystem interact (Corbin & Strauss, 2014). For example, codes

related to "collaborative partnerships" might be grouped with those addressing "resource sharing" or "policy support," highlighting the interdependence of these elements in fostering a successful innovation ecosystem.

Selective Coding: In the final phase, the researcher integrates the categories developed during axial coding into a central narrative or framework. Selective coding focuses on identifying the core category or theme that links the other categories together (Charmaz, 2006). In this study, the central theme is the development of a strategic framework for innovation ecosystems in Teaching Factory Agribusiness, which incorporates elements such as stakeholder engagement, resource sharing, policy support, and continuous learning.

The iterative nature of grounded theory ensures that data collection and analysis are continuous, with insights from early interviews informing subsequent interviews and guiding further exploration of emerging themes (Glaser & Strauss, 2017). Memo writing is also employed throughout the coding process to document the researcher's reflections, theoretical insights, and emerging hypotheses (Birks & Mills, 2022).

Validation and Trustworthiness

To ensure the rigor and trustworthiness of the findings, the study employs several strategies for validation (Lincoln & Guba, 1985): Triangulation: Data from different stakeholders (e.g., educators, industry partners, policymakers) are triangulated to compare perspectives and identify convergences or divergences in their experiences and views on innovation ecosystems in agribusiness (Denzin, 2012); Member Checking: After the initial data analysis, the researcher will share the emerging findings with a subset of participants to confirm that their experiences and views have been accurately represented (Birt et al., 2016); and Thick Description: The study will provide detailed descriptions of the participants' contexts and experiences to enhance the transferability of the findings to other educational and industry settings (Geertz & Darnton, 2017).

Ethical Considerations

Given the qualitative nature of the study, ethical considerations are paramount. All participants will be fully informed about the purpose of the study, and informed consent will be obtained before conducting interviews. Participants' anonymity and confidentiality will be preserved, and any sensitive information shared during interviews will be treated with strict confidentiality. The study will also comply with institutional ethical review board guidelines and will be conducted following the principles of ethical research outlined by the American Educational Research Association (AERA, 2011).

Limitations

As with any qualitative research, this study is subject to certain limitations. First, the reliance on purposive sampling means that the findings may not be generalizable to all agribusiness sectors or educational contexts. However, the depth of the qualitative insights generated is expected to provide valuable contributions to the development of a strategic framework that can be adapted to various settings. Additionally, the research is context-specific to agribusiness education, which may limit its applicability to other industries. Future research could expand on this study by exploring the innovation ecosystem framework in different sectors or regions.

Results

The results of this study present a strategic framework for building and sustaining innovation ecosystems in Teaching Factory Agribusiness, grounded in the experiences and insights of the 25 stakeholders interviewed. These stakeholders represent diverse roles within the agribusiness innovation ecosystem, including educators, industry partners, policymakers, and local community representatives. Through iterative coding and analysis, key themes emerged around collaboration, resource sharing, policy support, and the critical role of continuous learning in fostering innovation.

Emergent Themes from Open Coding

During the open coding phase, several key themes emerged from the interview data, each reflecting a critical component of the innovation ecosystem. The themes were organized into four broad categories: (1) collaboration and partnerships, (2) resource mobilization and sharing, (3) policy and institutional support, and (4) continuous learning and adaptation.

Table 1: Results of Data Analysis – Emergent Themes and Categories

Themes	Key Findings	Supporting Quotes/Examples	Related Literature
Collaboration and Partnerships	- Co-creation of solutions between universities, industry, and local communities. - Mutual benefits include access to knowledge and practical application in real-world settings.	"Our collaboration with universities helps us test innovative ideas in a controlled environment before scaling them in the field." - Industry Representative	Zhu et al. (2021); Rastorgueva et al. (2023)
Resource Mobilization and Sharing	- Sharing of tangible (funding, technology) and intangible (knowledge, expertise) resources between stakeholders. - Critical to innovation and operational success in Teaching Factory.	"Government initiatives have helped create funding mechanisms that support the development of innovation in agribusiness." - Policymaker	Wulandari et al. (2022); Sultana & Turkina (2023)
Policy and Institutional Support	- Supportive policies foster innovation by creating favorable environments for collaboration. - Some regulatory barriers hinder innovation (e.g., delays in research permits).	"The government's role in creating an environment that encourages innovation through financial incentives and regulatory support cannot be understated." - Industry Stakeholder	de Boon et al. (2022); Dawson Jr et al. (2024)

Collaboration and Partnerships

Collaboration between educational institutions, industry, and local communities was identified as a fundamental driver of innovation in agribusiness Teaching Factories. Interviewees consistently highlighted the importance of partnerships in enabling the co-creation of knowledge and solutions tailored to real-world agribusiness challenges (Zhu et al., 2021). As one industry representative stated:

"*Our collaboration with universities helps us test innovative ideas in a controlled environment before scaling them in the field. The Teaching Factory acts as a sandbox where we can experiment and co-create with students, professors, and researchers.*"

This view was echoed by educators, who emphasized the mutual benefits of such partnerships. Universities benefit from access to cutting-edge industry knowledge and technologies, while companies gain fresh perspectives and a workforce equipped with practical, hands-on experience (Rastorgueva et al., 2023).

Resource Mobilization and Sharing

The ability to mobilize and share resources, both tangible (e.g., funding, technology) and intangible (e.g., knowledge, expertise), was another key theme identified. Several participants noted that innovation ecosystems thrive when there is a free flow of resources between stakeholders, fostering an environment where innovation can occur without the typical constraints of limited funding or access to technology (Wulandari et al., 2022). One policymaker elaborated:

"*Government initiatives have helped create funding mechanisms that support the development of innovation in agribusiness. But equally important is the shared access to technology and expertise, which allows smallholder farmers and local communities to benefit from innovations that would otherwise be inaccessible to them.*"

The importance of resource sharing extends beyond monetary support to include intellectual property, training, and infrastructure, which are critical to supporting the Teaching Factory model.

Policy and Institutional Support

Policy support emerged as a central theme, with participants emphasizing the need for a conducive regulatory environment that supports innovation in the agribusiness sector. As noted in previous studies, the alignment of government policies with industry and educational goals is critical for sustaining innovation ecosystems (de Boon et al., 2022). Several interviews cited successful government programs that incentivized collaboration between universities and industries, such as tax breaks for companies involved in university research projects or grants for innovation in agricultural technologies. An industry representative shared:

"*Without favorable policies, many of our collaborations would have stalled. The government's role in creating an environment that encourages innovation through financial incentives and regulatory support cannot be understated.*"

However, challenges also emerged. Some interviewees noted that while certain policies support innovation, others—such as bureaucratic delays in approving research permits—act as barriers to the swift implementation of new ideas. This finding aligns with Dawson Jr et al. (2024), who emphasized the tension between regulatory frameworks and innovation ecosystems in agribusiness.

Continuous Learning and Adaptation

The concept of continuous learning—both for students in Teaching Factories and for industry professionals—was a recurring theme. Innovation ecosystems were seen as dynamic

entities that require constant learning and adaptation to evolving market and technological conditions. Educators emphasized the role of Teaching Factories in preparing students for real-world challenges through experiential learning, while industry stakeholders noted the importance of continuous professional development to stay abreast of new technological advancements (Sultana & Turkina, 2023; Wulandari et al., 2022). One educator commented:

"*In the Teaching Factory, students are not just learning theoretical concepts; they're applying them in real-world scenarios. This prepares them for the realities of agribusiness, where the ability to adapt and innovate is key to success.*"

Similarly, industry participants underscored the need for ongoing training and development programs to ensure that their workforce remains competitive in a rapidly changing agricultural landscape. This aligns with the concept of the learning organization, which has been widely discussed in the literature as a key component of innovation ecosystems (Zhu et al., 2021).

Axial Coding: Connecting Themes and Categories

During the axial coding phase, the four broad categories—collaboration and partnerships, resource mobilization and sharing, policy and institutional support, and continuous learning—were further refined to explore how they interact within the innovation ecosystem. Three key relationships were identified: Collaboration as an Enabler of Resource Mobilization: Collaboration between stakeholders was seen as a catalyst for resource sharing. Educational institutions provide access to research and innovation labs, while industry partners contribute funding, technology, and market insights. This reciprocal exchange of resources strengthens the innovation ecosystem by ensuring that all stakeholders have access to the tools and expertise needed to drive innovation (Kamilaris et al., 2017); Policy Support as a Foundation for Collaboration: Favorable policies were identified as a prerequisite for successful collaboration. Participants stressed that without institutional and governmental support, collaboration efforts would lack the necessary financial and legal backing to succeed. As noted by de Boon et al. (2022), policy alignment is critical to fostering a regulatory environment that encourages rather than hinders innovation; Continuous Learning as a Mechanism for Sustainability: Continuous learning was seen as the mechanism that sustains the innovation ecosystem over time. Through ongoing education and professional development, both students and industry professionals are equipped to adapt to emerging trends and technological advancements, ensuring that the ecosystem remains competitive and relevant (Sultana & Turkina, 2023).

Table 2: Axial Coding – Relationships between Themes

Category 1	Category 2	Relationship	Supporting Literature
Collaboration and Partnerships	Resource Mobilization and Sharing	Collaboration enables resource sharing by connecting stakeholders (universities, industries, and communities) who provide complementary assets and knowledge for innovation.	Kamilaris et al. (2017); Zhu et al. (2021)
Policy and Institutional Support	Collaboration and Partnerships	Policy support creates a foundation for collaboration by incentivizing joint projects between universities and industry (e.g., tax breaks, innovation grants).	de Boon et al. (2022); Dawson Jr et al. (2024)
Continuous Learning and Adaptation	Innovation Sustainability	Continuous learning ensures that innovation ecosystems remain sustainable by equipping stakeholders with the skills to adapt to changing conditions and technologies in agribusiness.	Sultana & Turkina (2023) ; Wulandari et al. (2022)

Selective Coding: Toward a Strategic Framework

The final phase of selective coding involved integrating the core categories into a cohesive strategic framework for innovation ecosystems in Teaching Factory Agribusiness. This framework consists of the following key components: Stakeholder Engagement and Collaboration: The active engagement of universities, industries, policymakers, and local communities is essential for co-creating solutions that address real-world agribusiness challenges. This collaboration fosters innovation by leveraging the diverse expertise of each stakeholder group; Resource Sharing and Accessibility: The free flow of resources—financial, technological, and intellectual—is critical to the success of the innovation ecosystem. Policies and collaborative agreements must ensure that all stakeholders have access to the resources they need to innovate and scale new ideas; Policy Alignment and Institutional Support: A supportive policy environment that aligns with the goals of the innovation ecosystem is essential. Governments play a key role in creating financial incentives and reducing regulatory barriers to innovation; Continuous Learning and Capacity Building: The innovation ecosystem must prioritize continuous learning and adaptation to ensure its sustainability. This involves integrating experiential learning into the educational curriculum and offering ongoing professional development opportunities for industry stakeholders.

Table 3: Strategic Framework for Innovation Ecosystems in Teaching Factory Agribusiness

Component	Description	Supporting Literature
Stakeholder Engagement and Collaboration	Active engagement of universities, industries, policymakers, and communities in co-creating solutions to agribusiness challenges.	Rastorgueva et al. (2023); Zhu et al. (2021)
Resource Sharing and Accessibility	Free flow of resources (financial, technological, and intellectual) among stakeholders, supported by favorable policies and agreements.	Kamilaris et al. (2017); Wulandari et al. (2022)
Policy Alignment and Institutional Support	Supportive policies that align with the goals of the innovation ecosystem, facilitating collaboration and reducing regulatory barriers to innovation.	de Boon et al. (2022); Dawson Jr et al. (2024)
Continuous Learning and Capacity Building	Prioritization of continuous learning and professional development to ensure the sustainability of the innovation ecosystem in response to evolving market trends and technologies.	Sultana & Turkina (2023); Wulandari et al. (2022)

Validation of Results

To validate these findings, member checking was conducted with a subset of interviewees to ensure that their perspectives were accurately represented. Participants confirmed that the strategic framework reflected their experiences and offered valuable insights into the development of innovation ecosystems in agribusiness. Additionally, data triangulation—comparing the views of educators, industry stakeholders, and policymakers—helped to confirm the consistency of the emergent themes across different participant groups (Denzin, 2012).

Discussion

The findings from the data analysis present a nuanced understanding of the innovation ecosystems within Teaching Factory Agribusiness. The results underscore the significance of collaborative relationships, resource mobilization, policy alignment, and continuous learning as critical components that collectively contribute to an effective innovation ecosystem. This discussion synthesizes these findings, relates them to existing literature, and highlights the theoretical and practical implications.

Understanding the Role of Collaboration

The emphasis on collaboration and partnerships aligns with the growing recognition in the literature that innovation is inherently a social process (Zhu et al., 2021). As highlighted by the interviewees, collaboration between diverse stakeholders—educators, industry professionals, and policymakers—serves as a catalyst for innovation, fostering the co-creation of knowledge and practical solutions. This finding reinforces the argument put forth by Rastorgueva et al. (2023), who advocate for interdisciplinary partnerships as a mechanism to bridge the gap between theoretical knowledge and practical application. The Teaching Factory model exemplifies this by creating an environment where students can actively engage with industry challenges, thereby enhancing their employability and fostering an innovation mindset.

Resource Mobilization as a Catalyst for Innovation

The results indicate that effective resource mobilization and sharing are pivotal for innovation. This finding supports the work of Wulandari et al. (Wulandari et al., 2022), who argue that access to resources—both financial and intellectual—enables stakeholders to explore innovative solutions. The insights from policymakers regarding funding mechanisms demonstrate that government support plays a crucial role in facilitating resource sharing. This reflects broader trends in agribusiness where collaborative funding and investment strategies are essential for driving innovation (de Boon et al., 2022).

Moreover, the tangible benefits of resource sharing underscore the importance of developing frameworks that promote equitable access to innovation resources, particularly for smallholder farmers and emerging agribusinesses. The interview data indicate a strong desire for policies that not only support collaboration but also ensure that resources are accessible to all participants within the ecosystem.

The Importance of Policy Support

The critical role of policy and institutional support emerged as a significant theme, reinforcing the argument that a conducive regulatory environment is essential for nurturing innovation ecosystems. While supportive policies can enhance collaboration and resource sharing, the findings also reveal challenges, particularly concerning bureaucratic barriers. Dawson Jr et al. (2024) have previously highlighted similar tensions, suggesting that policymakers must balance regulatory oversight with the need for innovation.

The insights gained from the interviews suggest that targeted policy interventions—such as simplifying regulatory processes and providing incentives for innovation—can significantly enhance the ecosystem's functionality. This dual focus on support and accountability is crucial for creating an environment where innovation can flourish.

Continuous Learning and Adaptation

The theme of continuous learning and adaptation highlights the dynamic nature of innovation ecosystems. As stated by Sultana & Turkina (2023), continuous learning enables stakeholders to stay abreast of new developments, thereby enhancing the ecosystem's resilience. The Teaching Factory's emphasis on experiential learning prepares students to tackle real-world challenges and encourages industry professionals to engage in ongoing professional development.

These findings suggest that educational institutions must adapt their curricula to reflect the rapidly changing agribusiness landscape, integrating new technologies and practices into their programs. This proactive approach not only prepares students for the future workforce but also ensures that the ecosystem remains responsive to emerging challenges and opportunities.

Conclusion and Implications

This research contributes to the growing body of literature on innovation ecosystems in agribusiness by providing a strategic framework grounded in empirical data. The findings offer valuable insights into how collaborative partnerships, resource sharing, policy support, and continuous learning are interlinked and essential for building sustainable innovation ecosystems within Teaching Factories.

Theoretical Implications

Theoretically, this study enhances our understanding of innovation ecosystems by integrating perspectives from various stakeholders within the agribusiness context. It underscores the need for a holistic approach that considers the interactions between collaboration, policy, resources, and learning. This framework can serve as a reference for future research exploring innovation in other sectors or educational models.

Practical Implications

Practically, the findings inform policymakers, educators, and industry leaders about the critical factors that contribute to successful innovation ecosystems. By fostering collaboration, ensuring equitable resource access, and creating supportive policies, stakeholders can enhance their collective capacity to innovate. Educational institutions can also leverage these insights to design curricula and programs that better prepare students for the demands of the agribusiness sector.

Future Research Directions

Future research could expand on this study by exploring the long-term impacts of the proposed strategic framework on innovation outcomes in agribusiness. Additionally, comparative studies between different regions or sectors could yield insights into best practices for building innovation ecosystems. Further investigations could also delve into the role of technology in facilitating collaboration and resource sharing, particularly in the context of digital transformation in agriculture.

In summary, the findings of this study provide a robust foundation for understanding and enhancing innovation ecosystems within Teaching Factory Agribusiness, paving the way for future research and practical applications aimed at fostering sustainable development in the agricultural sector.

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