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EXPERIENTIAL LEARNING IN FOOD ENGINEERING AS A STRATEGY FOR LOCAL FOOD SECURITY AND THE PRESERVATION OF TRADITIONAL FOOD KNOWLEDGE

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ABSTRACT

This study analyzed experiential learning in Food Engineering as a strategy to strengthen local food security and preserve traditional food knowledge. The research addressed the existing gap between predominantly industry-focused engineering education and the territorial realities of local food systems. A non-experimental, cross-sectional mixed-methods design with an exploratory-descriptive and correlational-explanatory scope was implemented. The sample included 68 students, 6 faculty members, and 18 community stakeholders participating in community-based experiential projects. Data were collected through a validated competency questionnaire (a = .93), semi-structured interviews, and structured observation. The results indicated high levels of theory-practice integration and strong perceived relevance of experiential activities to local food systems. Significant positive correlations were found between territorial participation and competency development, particularly in sociocultural ($r = .71$, $p < .001$) and systemic competencies ($r = .63$, $p < .001$). Regression analysis showed that experiential engagement explained 42% of the variance in overall competency development. Community stakeholders reported improvements in hygienic practices (83.3%), optimization of preservation processes (77.8%), and explicit valorization of traditional food knowledge (88.9%). The findings demonstrate that experiential learning not only strengthens technical and systemic competencies but also enhances cultural awareness and contributes to the resilience of local food systems. The study provides empirical evidence supporting the integration of territorially grounded experiential methodologies into Food Engineering curricula. It advances the field by linking pedagogical innovation with sustainability and food security objectives, highlighting the strategic role of higher education in fostering culturally respectful and technically sound food system transformation.

KEYWORDS: Experiential Learning, Food Engineering Education, Local Food Security, Traditional Food Knowledge, Community-Based Learning, Curriculum Innovation, Sustainable Food Systems, Professional Competencies.

1. INTRODUCTION

Food security constitutes one of the most significant structural challenges of the twenty-first century, not only due to its productive and technological dimensions, but also because of its profound articulation with cultural, social, and educational systems. In the current context (characterized by climate crises, socioeconomic inequalities, and accelerated transformations in agri-food systems) it is recognized that the education of Food Engineering professionals must transcend the traditional technical-industrial approach to incorporate competencies related to sustainability, territory, and food culture (Knorr & Augustin, 2023a, 2023b; Mumah et al., 2025).

Several studies indicate that food systems face tensions arising from productive homogenization and the progressive loss of traditional food practices, which affects both biodiversity and public health (Akinola et al., 2020; Sarkar et al., 2020). In Latin America and other regions with a strong presence of Indigenous peoples, the erosion of ancestral food knowledge compromises not only cultural heritage but also local resilience strategies in the face of food insecurity (Amaya-Castellanos et al., 2022; Lopes et al., 2024). Recent literature emphasizes that the revitalization of native foods and traditional systems can significantly contribute to healthier and more sustainable diets (Akinola et al., 2020; Lopes et al., 2024). However, such approaches are not yet systematically integrated into engineering curricula.

At the same time, higher education is undergoing a pedagogical transformation oriented toward active methodologies. Experiential learning, project-based learning, and service-learning have emerged as effective strategies for developing technical competencies, critical thinking, and social responsibility among engineering students (Akiri et al., 2025; de Reviere et al., 2024; Oliveira & Cardoso, 2021). In the specific field of chemical and food engineering, interdisciplinary practical approaches strengthen the integration of scientific knowledge with real-world challenges (Prado, 2021; Ruayruay et al., 2020). Likewise, service-learning applied to food systems promotes university–community engagement and fosters an understanding of food security from a territorial perspective (Belarmino et al., 2022; Nole Correa et al., 2025).

Recent research by Dunne et al. (2024) highlights that embedding sustainability as a signature pedagogy in food-related degrees enhances the development of systemic competencies. Similarly, Shafto et al. (2023) demonstrate that experiential culinary education improves understanding of food systems and strengthens professional confidence among future specialists. Gray et al. (2024) underscore the need to train professionals with explicit knowledge of food insecurity, given the persistent educational gaps in health- and food-related disciplines.

Nevertheless, although there is a growing body of research on pedagogical innovation in engineering (Malekshahian et al., 2025; Weston et al., 2020) and on the preservation of traditional food practices (Knorr & Augustin, 2023a; Amaya et al., 2022), a gap remains in the literature regarding the explicit articulation between experiential learning in Food Engineering, local food security, and the preservation of traditional knowledge. Most studies address these axes separately: on the one hand, technical training and competency development; on the other, sustainability and food systems; and, in another line of inquiry, the recovery of ancestral knowledge. However, an integrative model that links practical training with the revitalization of local knowledge as a concrete strategy to strengthen territorial food security is not yet clearly evidenced.

Moreover, the legacy of traditional food preservation and processing technologies, documented by Knorr and Augustin (2023a), offers a conceptual bridge between technological innovation and cultural heritage. Integrating this perspective into formative experiences enables students to understand engineering not merely as industrial optimization but as a tool for sociocultural valorization. The literature also emphasizes that competency-based curriculum design requires systematic mapping and alignment with social needs (Weston et al., 2020), an aspect that remains underexplored in relation to food sovereignty and local food security.

From a systemic perspective, the transition toward more resilient food systems requires professionals capable of engaging with communities, understanding local value chains, and applying scientific knowledge to specific contexts (Knorr & Augustin, 2023b). However, Food Engineering programs frequently maintain a predominantly industrial focus, centered on standardized processes and technological scaling, with limited direct interaction with rural territories or traditional knowledge systems.

This scenario defines an academic and social problem: the disconnection between Food Engineering education and the real needs of local food security, particularly in territories where traditional food practices with productive and nutritional potential persist. The absence of pedagogical strategies that integrate experiential learning with the preservation of food knowledge limits the transformative contribution of higher education institutions.

The present research is justified, first, by its contribution to pedagogical innovation in higher education, proposing a training model that articulates theory, practice, and territorial engagement. Second, it responds to the need to strengthen food security from a local perspective, recognizing the strategic value of traditional knowledge in the diversification and sustainability of food systems (Akinola et al., 2020; Sarkar et al., 2020). Finally, it contributes to the development of integrative curricular frameworks in engineering aligned with contemporary challenges of sustainability and community development (Dunne et al., 2024; Malekshahian et al., 2025).

In this context, the general objective of this study is to analyze how experiential learning in Food Engineering can serve as an effective strategy to strengthen local food security and contribute to the preservation of traditional food knowledge. The specific objectives are: (1) to identify the theoretical and pedagogical foundations supporting the integration of experiential methodologies into the curriculum; (2) to examine the relationship between territorial learning experiences and the development of professional competencies; and (3) to assess the potential of these strategies to generate impact in local communities in terms of cultural valorization and improvement of food practices.

The scope of this proposal lies in offering a conceptual and applied framework that links professional training, pedagogical innovation, and food sustainability, providing evidence for curricular redesign in Food Engineering and contributing to the contemporary debate on the role of higher education in transforming food systems.

2. METHODOLOGY

2.1. *Method*

The study was conducted under a mixed-methods approach, integrating quantitative and qualitative procedures in a complementary manner. This methodological decision was grounded in the need to analyze both the development of professional competencies (measurable through structured instruments) and the formative experience and its territorial impact (interpretable through narratives and social processes). According to Hernández et al. (2014), mixed methods enable a more comprehensive understanding of a phenomenon by combining objective measurement with interpretative analysis. Furthermore, the study adopted an applied educational research perspective aimed at improving training processes, consistent with Bisquerra's (2009) conception of educational research oriented toward intervention.

Regarding the type of research, it was classified as applied, since it sought to generate knowledge useful for curricular redesign in Food Engineering and for the implementation of formative strategies linked to local food security.

The design was non-experimental and cross-sectional. Independent variables were not manipulated; instead, existing relationships were observed and analyzed between the implementation of experiential learning activities and the development of competencies, as well as their perceived impact on local communities. The cross-sectional nature responded to the fact that data collection was conducted at a single academic point, corresponding to a specific semester.

The level of research was exploratory-descriptive with correlational-explanatory scope. It was exploratory because it addressed a scarcely integrated topic in the literature (experiential learning, local food security, and traditional knowledge); descriptive because it characterized the formative experiences and competencies developed; correlational because it examined the relationship between participation in territorial experiences and the development of professional competencies; and explanatory because it sought to interpret the potential impact on the preservation of traditional food knowledge. Hernández et al. (2014) indicate that these levels may be progressively integrated within a single study when the aim is to understand complex educational phenomena.

2.2. *Participants*

The population consisted of undergraduate students enrolled in the Food Engineering program at a public Latin American university, faculty members of the program, and community stakeholders involved in traditional food practices within the intervention territory.

The sample was non-probabilistic and purposive, selected based on direct participation in experiential learning projects related to local food security. Inclusion and exclusion criteria were applied to ensure methodological coherence.

a. Inclusion criteria (students):

- Enrollment in the third year or above of the program.
- Participation in at least one territorial experiential learning project related to the

production, processing, or preservation of local foods.
- Provision of informed consent.

b. Exclusion criteria (students):
- Failure to complete the formative project.
- Absenteeism exceeding 30% of practical activities.

c. Inclusion criteria (community stakeholders):
- Active involvement in traditional food practices (producers, processors, or bearers of knowledge).
- Collaboration in academic project activities.

The final distribution of participants is presented in Table 1.

Table 1: Distribution of Participants.

Group	Population	Sample		Participation (%)
Students	120	68		56.7%
Faculty	12	6		50%
Community stakeholders	35	18		51.4%
Total	167	92		–

The purposive selection was justified because the study required participants with direct experience in the implementation of the formative model.

2.3. *Procedure*

The study was carried out in four sequential phases:

Phase 1: Design of the formative model. An experiential learning proposal was structured based on territorial projects, integrating content from food technology, microbiology, preservation techniques, and sensory analysis with local traditional practices.

Phase 2: Implementation. During one academic semester, students participated in community-based projects related to improving preservation processes, hygienic standardization, and nutritional valorization of traditional food products.

Phase 3: Data collection. The following instruments were applied:
- Professional Competencies in Food Engineering Questionnaire (PCFEQ), developed ad hoc, consisting of 32 Likert-scale items (five response options). It assessed technical, systemic, and sociocultural competencies.
- Content validity: evaluated through expert judgment (n = 5), obtaining an Aiken's V coefficient of 0.91.
- Reliability: overall Cronbach's alpha = 0.93.
- Semi-structured interviews with students and community stakeholders, aimed at exploring perceptions regarding learning processes, territorial impact, and the preservation of traditional knowledge.
- Structured observation guide, applied during practical activities to record university–community interaction and the application of technical knowledge.

Phase 4: Systematization and triangulation. Quantitative and qualitative findings were integrated to strengthen internal validity, following methodological triangulation criteria described by Bisquerra (2009).

2.4. *Data Analysis*

Quantitative analysis was performed using SPSS version 26. Descriptive statistics (mean and standard deviation) were calculated to characterize competency development.

To address the second specific objective, Pearson's correlation analysis was conducted between the level of territorial participation and scores in systemic and sociocultural competencies. Additionally, multiple linear regression analysis was performed to examine the predictive capacity of experiential participation on competency development.

Qualitative analysis was conducted using ATLAS.ti software. An open, axial, and selective coding procedure was followed. Emerging categories were linked to the research objectives: pedagogical foundations, competency development, and community impact.

Results integration was carried out through data convergence, comparing quantitative trends with qualitative narratives to comprehensively explain how experiential learning contributed to local food security and the preservation of traditional knowledge.

3. RESULTS

3.1. *Pedagogical Foundations of Experiential Learning in Food Engineering*

Descriptive statistics from the Professional Competencies in Food Engineering Questionnaire (PCFEQ) show high levels of agreement regarding the pedagogical relevance of experiential learning. Table 2 presents the mean scores for the dimensions associated with pedagogical integration.

Table 2: Perception of Pedagogical Foundations of Experiential Learning (n = 68 students).

Dimension	Mean (M)	SD	Interpretation
Integration of theory and practice	4.52	0.48	Very high
Relevance to local food systems	4.47	0.51	Very high
Interdisciplinary articulation	4.35	0.56	High
Ethical and sociocultural awareness	4.41	0.50	Very high

Results indicate that students perceive experiential learning as strongly integrating theoretical knowledge with practical application (M = 4.52). The high mean for relevance to local food systems (M = 4.47) confirms alignment between curricular content and territorial food realities.

Qualitative data reinforce these findings. Students report that community-based projects allow them to contextualize microbiological control, preservation techniques, and quality management within traditional production settings. Faculty members emphasize that experiential strategies foster reflective learning and systemic thinking. These findings address the first specific objective by identifying experiential learning as a pedagogical bridge between technical training and territorial engagement.

3.2. Relationship Between Territorial Participation and Competency Development

To address the second objective, Pearson's correlation analyses are conducted between level of participation in territorial activities (measured through hours of engagement and project complexity) and competency scores.

Table 3: Correlation Between Territorial Participation and Competencies (N = 68).

Competency Dimension	r	p-value	Strength
Technical competencies	0.46	< .01	Moderate
Systemic competencies	0.63	< .001	Strong
Sociocultural competencies	0.71	< .001	Strong

The results show statistically significant positive correlations across all dimensions. The strongest association is observed for sociocultural competencies ($r = 0.71$), indicating that greater territorial engagement corresponds to higher development of cultural sensitivity and community-oriented problem solving.

Multiple linear regression analysis further demonstrates that territorial participation significantly predicts overall competency development ($\beta = 0.58$, $p < .001$), explaining 42% of the variance ($R^2 = .42$). These results confirm that experiential engagement in local food systems is a substantial predictor of professional competency acquisition.

Observational records corroborate quantitative findings. Students who participate intensively in field activities demonstrate improved application of hazard analysis, standardization procedures, and process optimization adapted to small-scale traditional contexts.

3.3. Impact On Local Food Security and Preservation of Traditional Knowledge

The third objective examines the perceived community impact of experiential learning initiatives. Community stakeholders evaluate the collaboration through structured interviews, and responses are categorized into thematic dimensions.

Table 4: Community Perceptions of Impact (N = 18 Stakeholders).

Impact Dimension	Frequency (n)	Percentage (%)
Improvement in hygienic practices	15	83.3%
Enhancement of product preservation	14	77.8%
Valorization of traditional knowledge	16	88.9%
Increased market potential	12	66.7%

The majority of community participants (88.9%) affirm that collaboration with students contributes to the recognition and valorization of traditional food knowledge. Improvements in hygienic practices (83.3%) and preservation techniques (77.8%) indicate concrete technical contributions aligned with food safety standards.

Qualitative analysis identifies three central

categories:

- Technical strengthening of traditional processes. Community members report improvements in fermentation control, moisture reduction, and packaging practices without altering the cultural identity of products.
- Mutual knowledge exchange. Students acknowledge learning indigenous classification systems, seasonal production cycles, and ancestral preservation logic. This bidirectional exchange strengthens the preservation of knowledge systems.
- Strengthening of local food resilience. Stakeholders describe enhanced capacity to maintain production during supply chain disruptions due to improved storage and conservation methods.

Integration of quantitative and qualitative findings reveals convergence: experiential learning not only enhances student competencies but also produces measurable community-level improvements in food safety and knowledge preservation.

3.4. Integrated Analysis in Relation to Research Objectives

The first objective is fulfilled through evidence that experiential methodologies integrate theory, practice, and sociocultural awareness at high levels.

The second objective is addressed by statistically significant correlations and predictive relationships between territorial engagement and competency development, demonstrating the formative effectiveness of the model.

The third objective is achieved through documented community impact, including improvements in hygienic standards, preservation processes, and the explicit recognition of traditional knowledge as valuable cultural capital.

Collectively, results demonstrate coherence between pedagogical innovation and food security outcomes. Experiential learning in Food Engineering operates as a multidimensional strategy: it strengthens technical expertise, fosters systemic and sociocultural competencies, and contributes to the resilience of local food systems.

4. DISCUSSION

The interpretation of the results confirms that experiential learning in Food Engineering constitutes a formative strategy with integrated academic and social effects. The findings demonstrate high levels of theory–practice integration, significant development of systemic and sociocultural competencies, and tangible impacts on local food practices. These results acquire greater relevance when analyzed in light of recent literature on pedagogical innovation, food sustainability, and the preservation of traditional knowledge.

First, the high student ratings regarding theory–practice integration and territorial relevance of the curriculum confirm that experiential learning strengthens coherence between academic content and real-world contexts. This finding aligns with Akiri et al. (2025) and De Reviere et al. (2024), who demonstrate that project-based learning in engineering enhances the transfer of scientific knowledge to applied settings. Similarly, Oliveira and Cardoso (2021) argue that problem-oriented approaches promote innovation and academic entrepreneurship in food engineering programs. The present findings extend these contributions by showing that such integration not only strengthens technical competencies but also articulates cultural and territorial dimensions, an aspect less explored in previous research.

The significant development of systemic and sociocultural competencies associated with territorial participation represents one of the most relevant findings of the study. The strong correlation between intensity of participation and sociocultural competencies confirms that direct interaction with communities generates learning outcomes that transcend technical training. This result is consistent with Belarmino et al. (2022), who indicate that service-learning in food systems fosters critical understanding of community dynamics. Likewise, Nole et al. (2025) report that projects aligned with food security principles reinforce university social responsibility. The present study contributes quantitative evidence supporting these assertions and demonstrates that territorial engagement explains a substantial proportion of variance in competency development.

From a curricular perspective, the findings support Weston et al. (2020), who emphasize the importance of mapping professional competencies in food science programs. The evidence indicates that experiential learning consolidates competencies that are not fully developed in exclusively laboratory-based environments. Furthermore, the relationship between territorial engagement and systemic performance is consistent with Dunne et al. (2024), who argue that sustainability as a signature pedagogy enhances comprehensive understanding of food systems. In this sense, sustainability moves beyond an abstract transversal concept and becomes a concrete formative experience when articulated with community-based practices.

Regarding local food security, the results demonstrate perceived improvements in hygienic practices, preservation techniques, and cultural valorization. These findings are consistent with literature recognizing the importance of integrating traditional knowledge into contemporary sustainability strategies. Akinola et al. (2020) and Sarkar et al. (2020) highlight that food diversification based on indigenous crops and practices contributes to more resilient systems. The present study confirms that university training can act as a catalyst in strengthening these processes by providing technical knowledge without displacing the cultural identity of traditional products.

The explicit recognition of traditional knowledge identified in community perceptions aligns with the findings of Amaya et al. (2022), who warn of the progressive loss of ancestral practices and their implications for health and social cohesion. Similarly, Lopes et al. (2024) argue that the promotion of native foods requires integrated educational and community interventions. The results show that experiential learning in Food Engineering fulfills this integrative function by establishing bidirectional knowledge exchange between students and communities.

The technical strengthening of traditional processes observed in the study also relates to the contributions of Knorr and Augustin (2023a), who emphasize the legacy of traditional preservation technologies as scientific and cultural heritage. The evidence indicates that academic intervention does not replace local practices but optimizes critical variables such as microbiological control and moisture reduction while respecting product identity. This balance between technological innovation and cultural preservation constitutes a substantial contribution in contrast to modernization models that tend to homogenize production systems.

From a systemic standpoint, improvements in local food resilience are consistent with Knorr and Augustin (2023b), who argue that the transition toward sustainable food systems requires synergies between technology and social ecosystems. The study demonstrates that university training can function as an articulating node within these synergies. Moreover, the need for professionals with explicit knowledge of food insecurity, highlighted by Gray et al. (2024), is supported by the findings, as direct engagement with territorial challenges strengthens professional awareness of food vulnerabilities.

In terms of employability and professional competencies, Malekshahian et al. (2025) emphasize the existing gap between academic preparation and labor market demands. The evidence presented indicates that experiential learning contributes to narrowing this gap by developing transferable skills in real contexts. Complementarily, Ruayruay et al. (2020) underscore the importance of work-integrated learning in food engineering programs, which is reflected in the technical performance observed among participating students.

More broadly, the findings are situated within the global debate on food system transformation. Mumah et al. (2025) underscores persistent structural and policy gaps in addressing food insecurity. The study offers a concrete educational perspective, demonstrating that higher education can actively contribute to territorial solutions through innovative formative strategies. Finally, the experiential approach aligns with proposals advocating for taking food systems education "out of the classroom" to generate contextualized learning (Wegener et al., 2026).

5. CONCLUSIONS

The study demonstrated that experiential learning in Food Engineering constituted an effective formative strategy for articulating technical training with the territorial realities of local food systems. The results showed that the systematic integration of community-based projects into the curriculum strengthened coherence between theory and practice, thereby fulfilling the first objective aimed at identifying pedagogical foundations supporting this methodology. The implemented model fostered interdisciplinary integration and promoted the development of ethical and sociocultural awareness among students.

Regarding the second objective, territorial participation exhibited statistically significant associations with the development of technical, systemic, and (more markedly) sociocultural competencies. Quantitative evidence indicated that the intensity of practical engagement explained a substantial proportion of competency performance, while qualitative findings confirmed that direct interaction with communities promoted critical thinking, technological adaptability, and comprehensive understanding of food systems. These results indicated that experiential learning not only complemented traditional instruction but also expanded the professional profile of future food engineers.

Concerning the third objective, the findings showed that the formative interventions generated tangible effects within participating communities, particularly in improving hygienic practices, optimizing preservation processes, and explicitly valorizing traditional food knowledge. Scientific knowledge contributed to strengthening productive processes without displacing the cultural identity of local products. This outcome confirmed that the articulation between university and territory simultaneously contributed to strengthening local food security and preserving food heritage.

The study advanced the field of Food Engineering education by proposing and empirically validating a formative model that integrated technical, systemic, and sociocultural dimensions within a unified methodological framework. It addressed the fragmentation observed in previous studies by demonstrating that pedagogical innovation could be directly linked to sustainability and food resilience objectives. Furthermore, the research contributed to the broader debate on the role of higher education in transforming food systems, providing evidence that professional training could function as an active agent of territorial development.

From a practical perspective, the results suggested the relevance of structurally incorporating experiential learning strategies into Food Engineering curricula, particularly those oriented toward rural contexts or communities that preserve traditional knowledge. The findings underscored the importance of strengthening university–community partnerships as permanent mechanisms for co-constructing knowledge.

For future research, expanding the temporal scope through longitudinal studies was recommended in order to assess the sustainability of formative and community impacts over the medium and long term. Replicating the model in diverse geographic and cultural contexts was also proposed to evaluate its transferability and adaptability. Finally, further research was suggested to deepen the measurement of economic and nutritional impacts derived from academic intervention, thereby consolidating evidence regarding its structural contribution to food security.

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