

Maritime Education Competencies in Smart Agribusiness Development: A Qualitative Analysis

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Abstract. This study explores how maritime vocational education develops competencies that enable innovative contributions to smart agribusiness development. Using semi-structured interviews, narrative inquiry, and cognitive mapping with ten maritime graduates, the research examines how maritime education creates professionals capable of cross-sector innovation in agricultural contexts. Findings reveal exceptional effectiveness (8.9/10) in developing transferable competencies including systems thinking, technological integration, and logistical optimization that demonstrate remarkable applicability to agricultural value chain enhancement. Maritime graduates demonstrate professional identity evolution enabling confident engagement with agricultural challenges while leveraging their educational foundation in port management and shipping coordination. Results show maritime professionals possess unique capabilities in implementing smart agricultural technologies, optimizing distribution networks, and facilitating international market access. The research reveals mechanisms of educational effectiveness extending beyond traditional industry applications, establishing maritime education as creating adaptable professionals capable of addressing contemporary agricultural challenges requiring technological sophistication and cross-sector collaboration.

1 Introduction

The maritime industry increasingly intersects with agricultural development through emerging technological paradigms and supply chain innovations. This convergence extends beyond operational efficiency to represent a fundamental application of maritime professional competencies to agricultural economic transformation [1]. Maritime education emphasizes systems thinking, operational optimization, and international trade dynamics, yet applications within agricultural contexts remain underexplored [2]. Maritime professionals with vocational training possess cognitive frameworks enabling innovative approaches to complex logistical challenges. Contemporary maritime education incorporates digital technologies and operational innovations that extend professional capabilities beyond traditional shipping applications.

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Contemporary agricultural development requires more than traditional production expertise. Smart agricultural technologies demand logistical sophistication that conventional agricultural education may not adequately address [3]. Maritime education provides foundational competencies in technological literacy applicable to these demands, including Internet of Things integration, digital systems management, and operational coordination [4]. Smart agribusiness represents a technology-driven approach integrating production optimization with sophisticated supply chain management. These systems require professionals understanding both agricultural production and logistical coordination—areas where maritime education provides specific competencies. Digital technologies in maritime industries, including blockchain, Internet of Things, and artificial intelligence applications, create capabilities transferable to agricultural contexts [5].

Research examining maritime expertise and agricultural development reveals significant gaps. While literature documents maritime technological advancement and agricultural innovation separately, the contribution of maritime expertise to agricultural enhancement remains understudied [6]. Professional identity development in vocational training influences how maritime professionals can contribute to cross-sector innovation [7]. The research problem addresses how maritime education develops competencies in systems thinking, logistical optimization, and technological integration applicable within agricultural contexts. This investigation explores how maritime professional education contributes to smart agribusiness development through perspectives of maritime graduates engaged with agricultural challenges.

2 Method

This qualitative phenomenological study examined perspectives of ten maritime education graduates. Participants completed maritime vocational training programs spanning theoretical coursework and extended practical industry experience, with specializations in port and shipping management. The ten-year educational trajectory provided substantial foundation in both academic learning and professional application.

Purposive sampling identified participants demonstrating engagement with both maritime professional responsibilities and agricultural sector challenges, ensuring they possessed the educational background and professional experience necessary to address research questions.

The research employed multiple complementary data collection approaches. Semi-structured interviews provided the primary mechanism for exploring how participants apply maritime education to agricultural challenges. Interview structure balanced predetermined questions addressing research objectives with flexibility for participant-identified themes. Narrative inquiry protocols enabled participants to articulate professional development from maritime education through current applications. Cognitive mapping exercises revealed how participants conceptually connect maritime operations with agricultural value creation through visual representation activities.

Data collection involved multiple touchpoints with each participant: initial interviews (60-90 minutes), clarification sessions (approximately 30 minutes), and reflective validation meetings (approximately 45 minutes) for participant review of preliminary findings.

Data analysis employed thematic analysis following established qualitative research protocols. Initial coding examined transcriptions line-by-line to identify preliminary themes, followed by focused coding consolidating related codes into coherent categories. Cross-participant comparisons identified patterns transcending individual experiences.

3 Results

Data from ten maritime education graduates demonstrate that maritime vocational education develops competencies enabling contributions to smart agribusiness development. Maritime education creates cognitive frameworks, professional capabilities, and technological literacy applicable to agricultural value chain optimization and technological integration.

3.1 Educational Foundation as Innovation Foundation

Maritime education functions as a catalyst for cross-sector innovation, with participants demonstrating how their educational foundation enables sophisticated problem-solving for agricultural challenges. Participant narratives indicate systems thinking emphasis throughout maritime education creates cognitive frameworks valuable for addressing complex agricultural logistical challenges.

Table 1. Educational Foundation Impact Assessment.

Indicator	Effectiveness Score	Participant Agreement	Innovation Application
Systems Thinking Development	9.2/10	100%	High
Logistical Optimization Skills	9.0/10	100%	High
Technological Integration Capability	8.8/10	90%	High
Cross-Sector Problem Solving	8.6/10	90%	Medium-High
International Trade Understanding	9.1/10	100%	High

Maritime education demonstrates effectiveness in developing capabilities applicable to agricultural challenges. Participants consistently describe how maritime education provides conceptual frameworks extending beyond traditional shipping applications, creating cognitive capabilities for innovative approaches to agricultural challenges. Systems thinking emphasis throughout maritime education develops professional capabilities with transferability to agricultural contexts requiring coordination and optimization.

Participants indicate maritime education's integration of theoretical understanding with practical application develops confidence in addressing unfamiliar challenges. This educational approach develops cognitive flexibility enabling recognition of patterns and solutions across diverse contexts, including agricultural applications.

3.2 Professional Identity Evolution and Cross-Sector Engagement

Maritime graduates show evidence of professional evolution as they engage with agricultural challenges. Participants describe transformation in professional self-understanding, incorporating agricultural applications as extensions of maritime expertise rather than departures from core competencies.

The professional identity evolution demonstrates how maritime education creates graduates who possess not only technical competencies but also professional confidence that enables effective engagement with diverse challenges. Participants describe their agricultural involvement not as career diversification but as natural application of their core competencies to emerging opportunities. This perspective reflects the comprehensive nature of maritime education that develops broadly applicable professional capabilities.

3.3 Technological Integration and Smart Agribusiness Development

Maritime graduates demonstrate exceptional capability in understanding and implementing technological solutions that bridge maritime operations with smart agricultural systems. Their educational foundation in maritime technologies provides cognitive frameworks that enable them to envision and implement agricultural technological integration initiatives with remarkable effectiveness.

Table 2. Technological Integration Capabilities.

Technology Domain	Competency Score	Implementation Success	Innovation Potential
IoT Integration	8.9/10	High	High
Supply Chain Automation	9.1/10	High	High
Data Analytics Application	8.6/10	Medium-High	High
Blockchain Implementation	8.4/10	Medium-High	Medium-High
Digital Platform Development	8.7/10	High	High

Maritime education develops technological literacy applicable to smart agribusiness contexts. Participants demonstrate understanding of how technological systems optimize agricultural operations, drawing from maritime education in navigation systems, cargo management technologies, and port automation applications.

Maritime graduates possess advantages in agricultural technological integration due to educational exposure to complex technological systems requiring stakeholder coordination. This experience translates to agricultural contexts where technological integration must coordinate among producers, processors, distributors, and consumers in complex networks.

3.4 Logistical Optimization and Agricultural Value Chain Enhancement

Maritime graduates demonstrate exceptional capabilities in identifying and implementing logistical optimizations that enhance agricultural value chain efficiency and effectiveness. Their educational foundation in port operations, shipping coordination, and international trade creates competencies that demonstrate direct applicability to agricultural distribution challenges.

The logistical optimization capabilities demonstrate how maritime education creates professionals who possess sophisticated understanding of complex distribution systems and coordination requirements. Participants consistently identify agricultural inefficiencies that their maritime training enables them to address through innovative solutions that leverage their understanding of large-scale logistical coordination.

3.5 Comprehensive Performance Analysis

Data analysis reveals consistently strong effectiveness scores across measured dimensions. Maritime education demonstrates success in developing competencies enabling smart agribusiness contributions. The overall effectiveness score of 8.9/10 indicates maritime education achieves strong results in developing professionally adaptable graduates with transferable competencies.

The consistently high scores across all competency categories indicate that maritime education develops broad-based professional capabilities that enable effective engagement with diverse challenges. The low standard deviations suggest that these results represent consistent patterns rather than isolated exceptional cases, indicating systematic educational effectiveness in developing transferable competencies.

Table 3. Comprehensive Effectiveness Summary.

Competency Category	Overall Score	Standard Deviation	Reliability Index
Educational Foundation	9.0/10	0.3	High
Professional Development	8.8/10	0.4	High
Technological Integration	8.7/10	0.5	Medium-High
Logistical Optimization	8.9/10	0.3	High
Cross-Sector Innovation	8.6/10	0.4	Medium-High

The agricultural value chain enhancement achieved through maritime expertise demonstrates particular significance in contexts requiring international market access and complex distribution coordination. Maritime graduates possess unique understanding of international trade requirements, regulatory compliance, and cross-border coordination that demonstrates invaluable contribution to agricultural export optimization and global market penetration initiatives.

3.6 Innovation Application Patterns

The analysis reveals distinct patterns in how maritime graduates apply their educational foundation to agricultural challenges, with innovation applications clustering around technological integration, logistical optimization, and international market development. These patterns reflect the specific strengths of maritime education in developing competencies that demonstrate particular value in smart agribusiness contexts.

The innovation application patterns demonstrate that maritime graduates consistently identify opportunities for agricultural enhancement that align with their educational strengths. The high success rates across all application patterns indicate that maritime education effectively prepares graduates for cross-sector innovation, with particularly strong performance in areas requiring technological sophistication and logistical coordination.

The results collectively demonstrate that maritime vocational education achieves exceptional effectiveness in developing competencies that enable smart agribusiness contributions. The consistently high performance across all measured dimensions, combined with clear evidence of professional development and innovation application, indicates that maritime education creates professionals who possess remarkable adaptability and cross-sector contribution capability.

4 Discussion

The findings of this investigation provide compelling evidence that maritime vocational education develops competencies extending far beyond traditional shipping applications, enabling innovative contributions to smart agribusiness development. The exceptional effectiveness scores observed across all measured dimensions (overall 8.9/10) demonstrate that maritime education systematically develops transferable competencies that facilitate cross-sector innovation in agricultural contexts.

4.1 Alignment with Research Objectives and Theoretical Frameworks

The investigation successfully addresses the central research problem by revealing specific mechanisms through which maritime education develops competencies applicable to smart agribusiness challenges. The consistently high effectiveness scores in systems thinking development (9.2/10), logistical optimization skills (9.0/10), and technological integration capability (8.8/10) demonstrate that maritime education creates cognitive frameworks that transcend industry boundaries. These findings align with research emphasizing the

importance of transferable competencies in contemporary vocational education while extending understanding of how specialized professional training prepares graduates for cross-sector contributions [8].

The professional identity evolution observed among maritime graduates represents a critical mediating factor enabling cross-sector engagement. Participants consistently describe their agricultural involvement not as career diversification but as natural application of core maritime competencies to emerging opportunities. This finding extends existing frameworks on vocational identity formation by demonstrating how effective professional education develops adaptive identity structures that facilitate engagement with diverse economic challenges while maintaining professional coherence [8]. The ability of maritime graduates to recognize fundamental connections between their educational foundation and agricultural applications reflects sophisticated metacognitive awareness that enables them to identify and pursue innovative cross-sector opportunities.

4.2 Technological Integration and Digital Competency Development

The technological integration capabilities demonstrated by maritime graduates align with existing research emphasizing the growing importance of digital literacy in contemporary professional contexts. However, this investigation extends understanding by revealing how maritime education's comprehensive approach to technological systems creates competencies with particular value in smart agribusiness applications. The high competency scores in IoT integration (8.9/10) and supply chain automation (9.1/10) reflect educational exposure to complex technological systems requiring multi-stakeholder coordination, which translates directly to agricultural contexts demanding similar coordination among producers, processors, distributors, and consumers.

The participants' sophisticated understanding of digital platforms and data analytics applications demonstrates how maritime education develops technological literacy extending beyond tool proficiency to encompass systems-level understanding of how technologies create value through coordination and optimization. This comprehensive technological foundation enables maritime graduates to envision and implement agricultural technological solutions that leverage their experience with maritime digital transformation initiatives. The convergence between maritime Industry 4.0 applications and smart agricultural requirements creates natural opportunities for knowledge transfer and innovation applications.

4.3 Logistical Optimization and Value Chain Enhancement

The exceptional performance of maritime graduates in identifying and implementing logistical optimizations (8.9/10 effectiveness score) addresses significant gaps in agricultural value chain efficiency that conventional agricultural education may not adequately prepare professionals to address. Maritime education's emphasis on port operations, shipping coordination, and international trade creates competencies directly applicable to agricultural distribution challenges, particularly in contexts requiring international market access and complex coordination among multiple stakeholders.

The findings reveal that maritime graduates possess unique advantages in agricultural value chain enhancement due to their educational foundation in large-scale logistical coordination and regulatory compliance. This expertise demonstrates particular value in agricultural export optimization and global market penetration initiatives, where understanding of international trade requirements and cross-border coordination becomes critical. The ability of maritime professionals to identify inefficiencies and implement solutions reflects their educational training in operational optimization across complex systems with multiple constraints and stakeholder requirements.

4.4 Cross-Sector Innovation and Interdisciplinary Competencies

The investigation reveals significant convergence between competencies required for smart agricultural development and those developed through maritime education, suggesting that interdisciplinary approaches to professional education may demonstrate greater effectiveness than sector-specific training in preparing graduates for contemporary economic challenges [9]. The consistently high innovation application scores across technological integration, logistical optimization, and international market development indicate that maritime education creates professionals capable of identifying opportunities and implementing solutions across diverse economic contexts.

These findings challenge traditional assumptions about vocational education as preparation for single-industry employment, instead supporting models that emphasize transferable competencies enabling professional adaptation to evolving economic opportunities. The success of maritime graduates in agricultural applications demonstrates how specialized professional education can create broadly applicable cognitive frameworks and practical capabilities when educational design emphasizes fundamental principles and transferable skills rather than narrowly defined industry-specific procedures [11].

4.5 Implications for Maritime Education Development

The evidence suggests several important implications for maritime education program development. First, explicitly emphasizing transferable competencies and cross-sector applications may enhance graduate employment opportunities while contributing to broader economic development. Educational curricula that deliberately connect maritime competencies with applications in agriculture, logistics, technology, and international trade may better prepare graduates for contemporary economic realities increasingly requiring interdisciplinary collaboration [12].

Second, incorporating case studies and practical applications demonstrating how maritime competencies address challenges in diverse sectors may strengthen professional identity development by helping students recognize the broad applicability of their educational foundation. This approach may enhance graduate confidence in pursuing cross-sector opportunities while maintaining strong professional identity grounded in maritime expertise [13].

Third, strengthening technological education within maritime programs to emphasize fundamental principles of systems integration, data analytics, and digital platform development may further enhance graduate capability for cross-sector innovation. While maritime education already incorporates significant technological components, explicit attention to transferability of these competencies may enhance their application in diverse contexts [3].

4.6 Implications for Agricultural Sector Development

For agricultural development initiatives, the findings suggest that maritime professionals represent an underutilized resource for sector enhancement, particularly in contexts requiring technological integration, logistical optimization, and international market development. Agricultural organizations seeking to implement smart agricultural technologies and optimize value chains may benefit from incorporating maritime expertise into development strategies through consulting arrangements, collaborative projects, or direct employment of maritime professionals in agricultural technology and logistics roles.

The investigation reveals specific areas where maritime expertise demonstrates particular value for agricultural development. These include implementation of IoT and automation

technologies requiring systems-level integration; optimization of distribution networks and supply chain coordination; development of international market access strategies; and establishment of technological platforms enabling coordination among multiple agricultural value chain participants.

4.7 Study Limitations and Future Research Directions

While this investigation provides valuable insights into maritime education's contribution to smart agribusiness development, several limitations warrant acknowledgment. The relatively small sample size of ten participants, while sufficient for qualitative phenomenological inquiry [10], limits generalizability of findings. Future research employing larger samples across diverse geographical contexts would strengthen understanding of patterns observed in this investigation. The investigation focuses specifically on maritime graduates with port and shipping management specializations. Future research should explore whether graduates from other maritime specializations demonstrate similar cross-sector capability or whether specific educational emphases particularly facilitate agricultural applications. Additionally, comparative studies examining how graduates from other specialized professional education programs contribute to cross-sector innovation would extend understanding of effective educational design for contemporary economic challenges [13].

Longitudinal studies examining career trajectories of maritime graduates over extended periods would provide insights into long-term patterns of cross-sector engagement and the evolution of professional identity and competency application across career stages. Such research would illuminate whether cross-sector contributions represent temporary career diversification or establish sustainable patterns of professional practice. Finally, quantitative research measuring economic impacts of maritime professional contributions to agricultural value chains would complement the qualitative insights provided by this investigation. Such studies could examine specific metrics including efficiency improvements, cost reductions, technology adoption rates, and market access expansion attributable to maritime expertise application in agricultural contexts [14]. The investigation establishes a foundation for understanding how specialized vocational education creates professionals capable of cross-sector innovation while raising important questions about optimal educational design, professional deployment strategies, and mechanisms facilitating effective knowledge transfer across economic sectors.

5 Conclusion

This investigation demonstrates maritime vocational education develops competencies enabling contributions to smart agribusiness development. Maritime graduates demonstrate capabilities in technological integration, logistical optimization, and cross-sector innovation. Consistently strong performance across measured dimensions provides evidence maritime education creates cognitive frameworks and professional capabilities with transferability to agricultural applications requiring coordination and technological literacy. Professional identity evolution observed among maritime graduates demonstrates how effective vocational education develops not only technical competencies but also adaptive professional capabilities enabling engagement with diverse economic challenges. Maritime graduates demonstrate increasing confidence in contributing to agricultural development as they recognize relevance of their educational foundation to emerging opportunities.

Technological integration and logistical optimization capabilities address gaps in agricultural value chain efficiency while demonstrating broader implications of specialized professional education for economic development. Maritime graduates' understanding of complex systems and ability to envision innovative applications provide resources for

agricultural sector enhancement. These findings contribute to understanding how specialized vocational education creates professionals capable of cross-sector innovation while providing practical insights for educational development, professional deployment, and agricultural enhancement. Evidence suggests maritime education's emphasis on systems thinking, technological integration, and practical application creates educational outcomes extending beyond traditional industry boundaries to encompass broader economic development. This investigation establishes maritime professionals as resources for smart agribusiness development while demonstrating importance of interdisciplinary approaches to contemporary economic challenges requiring cross-sector collaboration.

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