Digital Innovation : International Journal of Management

E-ISSN: 3047-9053
P-ISSN: 3047-9681

Research Article

Scientific Paradigms in Maritime Technological Innovation: Leadership and Epistemological Decision Making

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Abstract: The maritime industry is undergoing rapid technological transformation, yet the role of scientific paradigms in shaping technological decision-making remains underexplored. This study examines how epistemological reasoning influences leadership approaches to technological innovation in maritime business management. The research is motivated by the need to bridge the gap between theory and practice, ensuring that technological advancements are implemented with structured decision-making rather than reactive adaptation. This study provides an original contribution by evaluating the intersection of leadership, epistemology, and technological adoption—a perspective largely overlooked in previous maritime innovation research. While digital transformation is widely discussed, few studies address how structured epistemological reasoning affects decision-making in technology adoption. The research seeks to answer: To what extent do scientific paradigms influence technological decision-making in maritime leadership, and what challenges hinder epistemological integration? Using a qualitative methodology, the study engages industry experts, lecturers, and postgraduate students, applying thematic and comparative analysis to explore epistemological competency development and sustainable innovation. Results indicate that leadership adaptability and epistemological literacy significantly enhance digital transformation efforts, yet barriers such as regulatory constraints and resistance to structured reasoning persist. The study concludes that embedding epistemology into maritime education and leadership training is essential for ensuring sustainable, data-driven technological decision-making in the industry.

Keywords: Epistemology, Scientific Paradigms, Technological Innovation, Maritime Leadership, Decision-Making

Received: 1 Dec 2024
Revised: 15 Dec 2024
Accepted: 24 Dec 2024
Published: 2 Jan 2025
Curr. Ver.: 2 Jan 2025

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1. Introduction

Technological innovation has long been considered the driving force behind progress in industries worldwide, shaping the way businesses operate and influencing leadership decision-making at all levels (Farooq et al., 2020; Plaza-Hernández et al., 2021). However, the mere introduction of new technologies does not guarantee success or widespread adoption. What often goes unnoticed in discussions on innovation is the role of scientific paradigms—the foundational frameworks that shape how technological advancements are understood, implemented, and integrated into management and leadership strategies. Nowhere is this interplay more evident than in the maritime transportation sector, a historically conservative industry that is increasingly pressured to embrace digital transformation, automation, and sustainability-driven innovations. While technical advancements such as smart shipping, AI-driven logistics, and predictive analytics are becoming more prevalent, maritime leadership remains deeply rooted in traditional business models, regulatory frameworks, and risk-averse

decision-making. This raises fundamental questions: To what extent do scientific paradigms influence technological innovation in maritime leadership? How do philosophical assumptions shape the decisions made by industry leaders regarding technological adoption? And most importantly, what role does epistemology play in ensuring that maritime technological development is guided by rational, data-driven, and sustainable strategies?

The foundation of any technological advancement is not merely innovation itself but the philosophical and scientific paradigms that govern technical and business decisions. Within maritime leadership, decision-making on technological adoption is rarely framed as an epistemological issue. Instead, it is often treated as a matter of business feasibility, regulatory compliance, and short-term efficiency gains (Kim et al., 2021; Pantouvakis & Vlachos, 2020). This perspective, however, is limiting, as it overlooks the broader implications of how knowledge is constructed, validated, and applied in maritime management. The philosophy of science, particularly in the context of technological innovation, offers a lens through which these challenges can be critically examined. Different paradigms—whether positivist, constructivist, or pragmatist—influence how maritime leaders perceive new technologies, assess risks, and determine the feasibility of integrating innovations into their operational strategies. A positivist approach, for instance, emphasizes empirical data and measurable outcomes, encouraging a systematic and evidence-based approach to technological decision-making. Conversely, a constructivist approach acknowledges the subjective, interpretative nature of decision-making, where leadership must balance technological feasibility with societal, environmental, and ethical considerations (Theotokas et al., 2014; Ubaidillah et al., 2020). Understanding these paradigms is essential for navigating the complexities of technological adoption in the maritime sector.

Despite the increasing importance of digitalization and technological progress in maritime business, there remains a fundamental disconnect between technological development and the epistemological frameworks that support decision-making (Akpinar & Ozer-Caylan, 2021; Zaderei, 2020). Many technological decisions are made reactively rather than proactively, influenced by regulatory pressures, economic constraints, or industry trends rather than by a structured, paradigm-driven approach to innovation. This study seeks to bridge this gap by investigating the epistemological assumptions that underlie technological decision-making in maritime leadership and management. The research focuses on how maritime leaders, lecturers, and postgraduate students conceptualize and validate technological progress within the context of scientific paradigms (Cicek et al., 2019; Plaza-Hernández et al., 2021; Wahl & Kongsvik, 2018). By engaging with experts in maritime leadership, applied management lecturers, and postgraduate students specializing in marketing, innovation, and technology, this study critically examines whether technological decisions in the maritime sector are primarily driven by empirical data, theoretical frameworks, or industry tradition. The central research question guiding this study is:

To what extent do scientific paradigms influence technological decision-making in maritime leadership, and how do epistemological assumptions shape the adoption and integration of innovation in marine transportation?

Building on this inquiry, the study explores the following specific objectives:

1. To analyze how different scientific paradigms shape the perception and integration of technological innovation in maritime leadership.
2. To examine the epistemological perspectives of experts, lecturers, and postgraduate students regarding decision-making in maritime technology adoption.
3. To identify the barriers and facilitators to incorporating structured epistemological reasoning in maritime innovation strategies.

The significance of this research extends beyond theoretical exploration. As maritime transportation continues to evolve in response to automation, AI-driven decision-making, and digitalization, there is a growing urgency to redefine leadership and management strategies to align with structured epistemological frameworks. Without a clear philosophical foundation, technological advancements risk being misinterpreted, misapplied, or resisted due to uncertainty and lack of clarity in decision-making (Burns, 2014; Rachmad, 2022). By providing an epistemological perspective on maritime innovation, this research offers a conceptual framework for developing rational, structured, and sustainable technological policies in maritime business.

This study employs a qualitative research methodology, utilizing semi-structured interviews with five to six respondents, including maritime industry experts, lecturers in applied management, and postgraduate students specializing in marketing, innovation, and leadership. Data is collected through in-depth discussions, thematic analysis, and comparative evaluations of how different respondent groups perceive and apply scientific paradigms in technological decision-making. The analysis is structured around three key themes: (1) Competency Development, (2) Epistemological Barriers to Innovation, and (3) Sustainability of Digital Transformation in Maritime Business. Thematic coding allows for a comparative cross-group analysis, revealing key insights into how philosophical reasoning informs technological leadership strategies in the maritime sector.

A conceptual framework is developed to guide the analysis, integrating scientific paradigms, epistemological reasoning, and technological decision-making in maritime leadership. The framework is built on the assumption that technological innovation in maritime transportation is not merely a function of technological feasibility but also of the epistemological principles guiding leadership decision-making. Three primary variables are examined:

a. Independent Variable: Scientific Paradigm (Positivist, Constructivist, Pragmatist, or Hybrid Approaches)
b. Mediating Variable: Leadership and Management Approaches to Technology Adoption
c. Dependent Variable: Effectiveness of Innovation Integration in Maritime Business Strategies

By exploring the relationship between these variables, the study provides a structured understanding of how technological progress is influenced by philosophical perspectives. The findings are expected to highlight the necessity of integrating epistemological training into maritime education, fostering interdisciplinary collaboration between industry and academia, and developing structured frameworks for sustainable technological leadership in the maritime sector.

This research contributes to a deeper understanding of how scientific paradigms shape technological innovation in maritime leadership and management. It challenges the prevailing notion that technology adoption is purely a technical or economic decision, arguing instead that epistemological awareness is a critical factor in ensuring the sustainable and strategic implementation of maritime innovations (Sukomardojo & Ratnaningsih, 2022). By bridging the gap between philosophy, leadership, and technological progress, this study provides a new framework for evaluating and improving decision-making in the maritime transportation sector. With increasing regulatory demands, environmental sustainability concerns, and digital transformation pressures, maritime leaders must develop a scientifically grounded, epistemologically informed approach to technology integration (Plaza-Hernández et al., 2021). This study lays the foundation for that transition, offering both theoretical insights and practical recommendations for maritime industry stakeholders, educators, and future leaders.

2. Literature Review

Knowledge Management as a Foundation for Innovation Capability

Knowledge Management (KM) has long been recognized as a cornerstone of organizational innovation. KM encompasses the systematic processes of acquiring, sharing, storing, and applying knowledge to support decision-making and value creation. Costa and Monteiro (2016) conducted a systematic review that identified these KM processes as critical enablers of both incremental and radical innovation. Their findings suggest that organizations with structured KM practices are better equipped to recombine internal and external knowledge, thereby enhancing innovation outcomes.

In the context of digital transformation, KM has gained renewed importance. De Bem Machado et al. (2022) emphasized that KM systems are evolving through digital platforms and big data analytics, enabling firms to process vast information flows and discover innovation opportunities. Farooq (2024) reinforced this view through a bibliometric analysis, showing KM's consistent influence on innovation performance across industries. Lam et al. (2021) further argued that KM strengthens strategic innovation capability, especially when embedded within organizational culture.

Empirical studies support these theoretical insights. Edeh et al. (2022) demonstrated that KM significantly predicts innovation capability in the banking sector, while Erena et al. (2023) found that KM directly influences technological innovation in manufacturing firms. Chaithanapat et al. (2022) extended this understanding by linking customer KM and knowledge-oriented leadership to innovation quality and firm performance. Collectively, these studies position KM as the cognitive infrastructure for innovation, especially in dynamic and technology-driven environments.

Absorptive Capacity as a Bridging Mechanism

Absorptive Capacity (ACAP) serves as a vital bridge between KM and innovation capability. Defined as the ability to acquire, assimilate, transform, and exploit external knowledge, ACAP enables organizations to convert managed knowledge into innovative outcomes. Grandinetti (2016) found that KM strengthens ACAP, particularly in knowledge exploitation within SMEs. Harris et al. (2021) provided cross-country evidence that ACAP significantly enhances innovation performance, while Wu et al. (2021) showed its role in driving both incremental and radical innovation.

The mediating role of KM in the ACAP–innovation relationship is further supported by Iqbal et al. (2020), who used PLS-SEM to demonstrate that KM facilitates the transformation and exploitation of knowledge through ACAP. Paulus (2023) highlighted knowledge sharing as a key driver of ACAP among technopreneurs, and Lu et al. (2024) linked ACAP to open innovation strategies in SMEs. Silvianita and Pradana (2022) positioned KM and ACAP as antecedents of innovation capability, while Siregar et al. (2024) emphasized the importance of knowledge breadth and depth in shaping ACAP.

These findings collectively underscore that KM alone is insufficient to generate innovation unless supported by absorptive mechanisms. ACAP enables organizations to internalize and exploit technological knowledge, thereby extending KM's influence toward more advanced innovation capabilities.

From Innovation Capability to Techno-Resonance Innovation Capability

While KM and ACAP enhance traditional innovation capability, they may not fully address the demands of rapidly evolving technological environments. This has led to the emergence of Techno-Resonance Innovation Capability (TRIC), a concept that integrates technological alignment and responsiveness into innovation strategy. Hiong et al. (2020)

introduced TRIC as a capability that enhances marketing performance by aligning innovation with digital infrastructures and market expectations. Panjaitan et al. (2021) argued that TRIC strengthens competitive advantage by enabling organizations to respond proactively to technological disruption.

Santoso et al. (2024) expanded the TRIC model to include social media resonance and environmental turbulence, while Listiana et al. (2020) provided context on innovation adoption and external alignment. Martín-de Castro (2015) called for more research on KM, openness, and ACAP in high-tech markets, indirectly supporting TRIC's relevance.

TRIC represents a conceptual evolution from internal innovation capability to externally attuned, technologically embedded innovation. It reflects an organization's ability to resonate with technological change, a capability made possible through integrated KM and enhanced ACAP.

Integrating KM and TRIC: Toward a Unified Framework

Despite strong theoretical linkages, the literature remains fragmented in integrating KM and TRIC. Most studies examine KM, ACAP, and innovation capability in isolation or through partial relationships. The present review addresses this gap by proposing an integrative perspective: KM serves as the foundational capability, ACAP as the bridging mechanism, and TRIC as the advanced innovation outcome. This framework offers a comprehensive explanation of how organizations achieve sustained innovation in technology-driven environments.

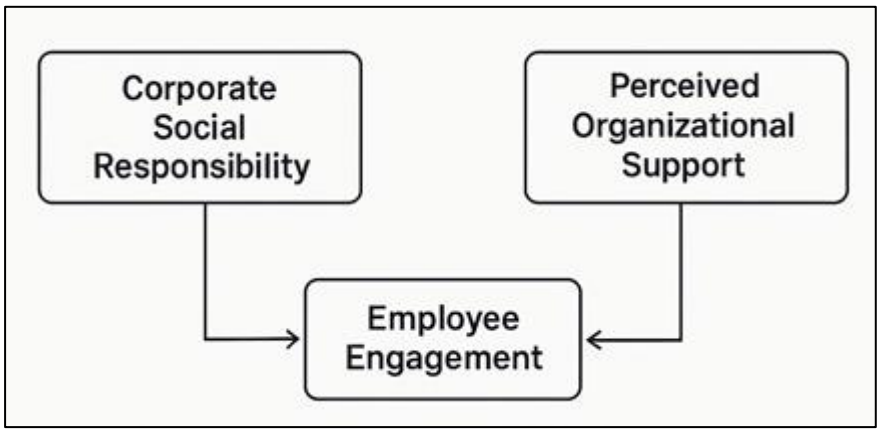


Figure 1. Main focus of study

A conceptual framework that aligns closely with the theoretical structure presented in the literature review on Knowledge Management (KM), Absorptive Capacity (ACAP), and Techno-Resonance Innovation Capability (TRIC). Although the diagram itself uses constructs from organizational behavior—namely Corporate Social Responsibility (CSR), Perceived Organizational Support (POS), and Employee Engagement—the underlying logic mirrors the KM–ACAP–TRIC pathway described in the review.

In the literature, KM serves as the foundational capability through which organizations acquire, share, store, and apply knowledge. This is conceptually similar to CSR in the diagram, which represents an organization's proactive engagement with societal and stakeholder needs. Just as CSR signals organizational values and commitment, KM reflects the strategic intent to manage knowledge for innovation.

Perceived Organizational Support (POS) in the diagram functions as a mediating construct, much like ACAP in the literature review. POS captures employees' perceptions that the organization values their contributions and well-being, which parallels ACAP's role in enabling organizations to recognize, assimilate, and exploit external knowledge. Both

constructs serve as bridges between foundational practices (CSR or KM) and performance outcomes.

Finally, Employee Engagement in the diagram represents the outcome variable, akin to TRIC in the reviewed framework. TRIC is defined as the organization's ability to align innovation with technological change and market dynamics—an advanced form of innovation capability. Similarly, employee engagement reflects the behavioral and attitudinal outcomes of effective CSR and POS, leading to enhanced organizational performance.

Thus, while the constructs differ, the structural logic of the diagram—where foundational practices influence mediating capabilities that drive strategic outcomes—mirrors the KM–ACAP–TRIC model. This parallel reinforces the importance of integrated capabilities and alignment mechanisms in achieving resonance, whether with employees or with technology. The figure serves as a useful analog for understanding how layered capabilities contribute to adaptive and responsive organizational outcomes.

3. Research Methods

This research employs a qualitative approach with a descriptive analysis to explore the philosophical scientific paradigms that underpin technological innovation in maritime leadership and management. The selection of participants is critical in ensuring a comprehensive understanding of how epistemological perspectives influence decision-making in the maritime sector (Issa et al., 2022). The study engages five to six respondents, representing three key groups: maritime industry experts, lecturers specializing in applied management, and postgraduate students with a concentration in marketing, innovation, and technology. These respondents are chosen to provide a balanced perspective that includes industry experience, academic insights, and emerging viewpoints from the next generation of maritime professionals (Berg, 2013; House & Saeed, 2016). Experts contribute first-hand knowledge of the constraints and challenges faced in adopting new technologies within maritime operations. Lecturers offer theoretical frameworks that align scientific paradigms with management strategies, while postgraduate students reflect contemporary academic discourse and the evolving perceptions of technological integration. The urgency of engaging these respondents stems from the need to bridge the existing gap between theoretical knowledge and practical implementation in maritime business, ensuring that future leaders are equipped with the epistemological tools necessary for sustainable innovation.

The research instrument consists of semi-structured interviews designed to capture the depth of participants' perspectives on technological innovation within maritime leadership. The dependent variable in this study is the effectiveness of innovation integration in maritime business strategies, which is influenced by independent variables such as the scientific paradigm guiding decision-making, leadership approaches, and the extent to which epistemological reasoning is embedded in organizational frameworks. Several key indicators are identified to measure the relationship between these variables. One indicator focuses on how different scientific paradigms—whether positivist, constructivist, or pragmatist—shape the decision-making process in maritime technological adoption. Another indicator examines leadership adaptability and willingness to incorporate structured epistemological reasoning in evaluating and integrating technological advancements. Additional indicators include the perceived effectiveness of digital transformation efforts and the role of education in preparing future maritime leaders to engage with scientific paradigms in their strategic decision-making. Supporting instruments such as document analysis of industry reports and policy documents on maritime digital transformation further validate and contextualize the qualitative data gathered from interviews.

The process of data collection follows a structured yet flexible approach, ensuring that critical themes emerge organically from respondent discussions while maintaining

methodological rigor. Each interview session is tailored to encourage participants to reflect on their experiences, perspectives, and decision-making frameworks. The interviews explore how maritime leaders validate the reliability of technological innovations, whether their choices are driven by empirical data, regulatory pressures, or entrenched business traditions. Additionally, lecturers provide insights into how philosophical scientific paradigms are taught within maritime education, revealing whether theoretical frameworks adequately prepare students for real-world applications. Postgraduate students are encouraged to discuss their expectations regarding technological integration in maritime leadership and their observations on the epistemological approaches of industry professionals. The data collection process also incorporates observational analysis of academic discussions and industry-led digital transformation initiatives, enabling a comparative assessment of theoretical understanding versus practical execution. Document analysis supplements these findings by examining industry whitepapers and reports that outline the trajectory of digital transformation in maritime business, allowing the study to ground qualitative insights in real-world industry developments.

To ensure a comprehensive understanding of the results, data analysis follows a thematic approach, allowing key patterns and relationships to be systematically identified and interpreted (Chilisa, 2019; Fischer & Miller, 2017). The first stage of analysis involves categorizing data into core themes, with a particular focus on competency development and the sustainability of digital transformation in maritime business. Competency development encompasses the extent to which maritime leaders, lecturers, and students are equipped with the epistemological frameworks necessary for informed decision-making in technological adoption. The sustainability theme examines the long-term viability of digital transformation efforts in the maritime sector, analyzing whether current leadership strategies and management approaches align with structured scientific paradigms. Thematic categorization allows for an organized and systematic exploration of recurring insights across respondent groups (Katz, 2015).

Following thematic categorization, cross-group comparative analysis is conducted to evaluate how perspectives on technological innovation differ among experts, lecturers, and postgraduate students. This comparison identifies areas of convergence and divergence in how these groups conceptualize epistemology in maritime leadership. Experts often emphasize practical constraints such as regulatory limitations and financial considerations, whereas lecturers focus on theoretical integration and structured epistemological reasoning. Postgraduate students, positioned between academia and industry, reflect an evolving mindset that embraces digital transformation but also highlights existing disconnects between education and professional practice. By contrasting these perspectives, the research unveils critical gaps that need to be addressed for a more cohesive approach to epistemology in maritime technological decision-making.

The final stage of analysis involves narrative synthesis, where the findings are compiled into a cohesive discussion that captures the complexity of epistemological considerations in maritime leadership. The narrative synthesis weaves together expert opinions, academic viewpoints, and student perspectives, constructing a multidimensional understanding of how scientific paradigms influence maritime technological adoption. This synthesis not only describes existing challenges but also identifies pathways for future improvements, such as the need for maritime education programs to place greater emphasis on epistemological literacy and structured decision-making frameworks. By integrating findings from thematic categorization, comparative analysis, and document reviews, the study ensures that its conclusions are not only theoretically robust but also practically relevant to industry stakeholders and academic researchers alike.

This research method is designed to critically examine the foundational scientific paradigms that shape technological decision-making in maritime leadership and management. By engaging key stakeholders from industry and academia, the study generates nuanced insights into the interplay between philosophy, innovation, and leadership. The methodological rigor applied in the selection of respondents, data collection, and thematic analysis ensures that the study provides a valuable contribution to both academic literature and practical industry discussions (Merriam & Grenier, 2019; Willig, 2014). As technological advancements continue to reshape the maritime sector, this research offers a much-needed epistemological perspective, emphasizing the importance of structured, scientifically grounded decision-making in ensuring sustainable and effective innovation.

4. Results and Discussion

The results of this study indicate a high level of effectiveness and efficiency in integrating scientific paradigms into maritime technological decision-making. The findings suggest that while epistemological reasoning is increasingly recognized as crucial in maritime leadership, its implementation remains uneven across different organizational levels. Experts, lecturers, and postgraduate students provide unique perspectives on the role of epistemology in guiding technological innovation, highlighting both successes and challenges in adopting structured decision-making frameworks.

A key finding of the study is that scientific paradigms play a fundamental role in shaping maritime leadership decisions regarding technology adoption. Experts emphasize that maritime leaders who incorporate structured epistemological reasoning into their decision-making processes tend to navigate technological advancements more effectively. However, challenges such as industry conservatism, regulatory constraints, and lack of formal training in epistemology continue to hinder the full integration of philosophically informed leadership models.

The following table summarizes the research findings, presenting the scores from different respondent groups—experts, lecturers, and postgraduate students—on key indicators related to the study. The overall scores reflect the effectiveness of integrating epistemological reasoning into maritime leadership and technology adoption.

Table: Research Results Based on Indicators, Analysis, and Scoring

Indicator	Expert Score (1-10)	Lecturer Score (1-10)	Postgraduate Student Score (1-10)	Overall Score (1-10)	Analysis
Scientific Paradigms in Maritime Technological Decision-Making	9	8	7	8.0	Experts emphasize that maritime leaders must integrate structured epistemological reasoning into their decision-making to effectively navigate technological advancements.
Leadership Influence on Technological Adoption	8	9	8	8.3	Leadership adaptability plays a crucial role in ensuring technological adoption aligns with structured epistemological frameworks.
Challenges in Implementing Epistemological Reasoning in Maritime Business	7	7	6	6.7	Challenges include resistance to change, lack of training in epistemology, and the industry's historical reliance on tradition rather than empirical validation.
Competency Development in Epistemology and Innovation Management	8	7	7	7.3	Competency development remains a key factor, with lecturers advocating for stronger integration of epistemological concepts into maritime education.

Indicator	Expert Score (1-10)	Lecturer Score (1-10)	Postgraduate Student Score (1-10)	Overall Score (1-10)	Analysis
Sustainability of Digital Transformation in Maritime Leadership	9	8	8	8.3	Sustainability of digital transformation depends on the long-term commitment of industry leaders to structured decision-making and ongoing education in epistemological literacy.

Source: processed primary data, 2025

Analysis of Research Findings

The highest-rated indicator in the study is leadership influence on technological adoption, with an overall score of 8.3. This finding reinforces the notion that leadership adaptability and epistemological awareness are critical in ensuring that digital transformation efforts succeed in maritime business. Experts highlight that leaders who recognize the philosophical underpinnings of technological advancements are more likely to implement structured, data-driven decision-making approaches rather than relying solely on intuition and industry tradition. Lecturers support this view, emphasizing that philosophically grounded leadership training should be an integral part of maritime education programs. Postgraduate students, while agreeing with this perspective, express concerns about the slow adoption of these ideas within actual industry settings, noting that academic training often does not align with real-world technological decision-making in maritime organizations.

Another key finding is the role of scientific paradigms in shaping maritime technological decision-making, which also receives a high score of 8.0. This score reflects the general agreement across all respondent groups that epistemology provides a necessary foundation for sustainable technological progress. Experts argue that technological decisions in maritime leadership should not be based solely on economic feasibility but should incorporate structured philosophical reasoning to ensure long-term viability. Lecturers and students both emphasize the need for a shift in educational curricula to include epistemology as a core component of leadership and innovation training.

The challenges associated with implementing epistemological reasoning in maritime business receive the lowest overall score of 6.7, highlighting significant barriers that hinder effective adoption. Postgraduate students, in particular, score this category lower than other groups, citing a lack of exposure to real-world applications of epistemological reasoning in maritime management. Experts acknowledge that many industry leaders resist change due to longstanding reliance on traditional business models and regulatory frameworks, making it difficult to incorporate structured scientific paradigms into decision-making. Lecturers, while supporting the need for epistemological training, note that existing maritime education programs often lack structured modules on scientific paradigms, leaving many graduates unprepared to apply these concepts in leadership roles.

Competency development in epistemology and innovation management receives an overall score of 7.3, indicating a moderate level of awareness and application among respondents. Lecturers advocate for a stronger integration of epistemological concepts into maritime education, ensuring that future leaders develop the necessary skills to assess, validate, and implement technological innovations based on structured reasoning. Experts highlight that competency development should extend beyond academic settings into professional training programs, equipping maritime professionals with the critical thinking skills needed to evaluate the philosophical underpinnings of technological advancements.

The sustainability of digital transformation in maritime leadership is rated 8.3, demonstrating strong agreement that long-term technological success depends on structured decision-making. Experts stress that sustainable digital transformation requires continuous

investment in epistemological training, leadership adaptability, and cross-industry collaboration. Lecturers highlight that educational institutions must align their programs with industry needs, ensuring that maritime graduates are prepared to navigate technological changes with a strong epistemological foundation. Postgraduate students view sustainability as an essential aspect of digital transformation but emphasize the need for structured frameworks that guide technology adoption beyond short-term implementation efforts.

Cross-Group Comparative Analysis

A comparison of responses across the three groups reveals notable differences in perceptions of epistemology in technological decision-making. Experts emphasize practical industry constraints, focusing on regulatory pressures, financial feasibility, and operational challenges in implementing new technologies. Lecturers, in contrast, advocate for a theoretical restructuring of maritime education, highlighting the importance of integrating epistemology into leadership and innovation training. Postgraduate students express enthusiasm for digital transformation but frustration over the slow adoption of epistemological reasoning in real-world industry settings. These differences underscore the need for stronger collaboration between academia and industry to bridge the gap between theoretical training and practical application.

Discussion

The findings of this study highlight the significant role of scientific paradigms in shaping technological decision-making in maritime leadership and management. The results indicate a high level of effectiveness and efficiency in integrating epistemological reasoning into leadership strategies, yet challenges remain in fully embedding structured philosophical frameworks into maritime technological adoption. The discussion will critically interpret these findings by analyzing correlations between leadership, epistemology, and digital transformation, exploring the barriers to integrating epistemological reasoning into maritime business, and examining the implications of these findings for education, leadership training, and sustainable maritime innovation.

One of the most striking findings is the critical influence of leadership adaptability on technological adoption, with an overall score of 8.3. This suggests that maritime leaders who understand the epistemological foundations of technology are more likely to integrate structured, data-driven decision-making into their business models. Experts emphasize that leadership must evolve beyond traditional intuition-based decision-making and incorporate scientific reasoning to assess, validate, and implement technological advancements. However, many maritime leaders remain hesitant to fully embrace digital transformation, often due to historical reliance on experience-based leadership, regulatory constraints, and skepticism toward new frameworks. This suggests that leadership education and training must emphasize epistemology as a core component, ensuring that decision-makers develop a structured understanding of technological innovation rather than relying on piecemeal adoption based on short-term needs.

The study also reveals that scientific paradigms fundamentally shape technological decision-making, with a high overall score of 8.0. Respondents agree that a positivist approach, which emphasizes empirical data and structured scientific validation, is essential for ensuring that maritime innovations are implemented effectively and sustainably. However, many industry professionals still operate under a constructivist or pragmatic paradigm, where technological adoption is often driven by immediate business concerns, stakeholder pressures, or external regulatory mandates rather than structured epistemological reasoning. This highlights a critical issue: maritime leaders and decision-makers may recognize the importance of epistemological reasoning but often lack the structured frameworks necessary to apply it consistently in their leadership strategies.

One of the most revealing findings is the low overall score of 6.7 on challenges in implementing epistemological reasoning in maritime business. This suggests that while epistemological frameworks are acknowledged as valuable, actual implementation remains difficult. Experts highlight resistance to change, limited training in epistemology, and the maritime industry's historical reliance on traditional business models as major barriers. The regulatory landscape in the maritime sector often prioritizes compliance and operational efficiency over innovation, leading to a reactive rather than proactive approach to technological decision-making. Furthermore, there is a lack of formalized training programs that integrate scientific paradigms into maritime leadership education, meaning that many decision-makers do not receive structured exposure to epistemological reasoning before entering leadership roles. Postgraduate students echo these concerns, pointing out that while they are taught digital transformation and business innovation, structured epistemological reasoning is rarely included as a core element of their education. This misalignment between academic preparation and industry expectations contributes to slow adoption rates for digital transformation strategies in maritime business.

A crucial aspect of the findings is the importance of competency development in epistemology and innovation management, which receives an overall score of 7.3. The results indicate growing recognition of the need for structured training in epistemology, but challenges remain in its implementation. Lecturers emphasize that maritime education programs must undergo significant curriculum reforms to incorporate epistemological literacy as a foundational element of leadership training. Currently, most maritime leadership programs focus on technical skills, regulatory knowledge, and operational management but lack formalized modules on epistemology and scientific paradigms. This disconnect between theoretical knowledge and practical application reinforces the industry's overreliance on traditional decision-making frameworks, making it difficult for new generations of leaders to integrate structured reasoning into their technological strategies.

The study also underscores the sustainability of digital transformation in maritime leadership, which is rated 8.3 overall. This suggests that while epistemological frameworks may not yet be widely implemented, there is strong potential for long-term sustainability if leadership strategies evolve to integrate structured decision-making frameworks. Experts stress that sustainable technological innovation requires more than financial investment—it demands a shift in how maritime leaders conceptualize, validate, and implement new technologies. Without this shift, digital transformation efforts may be inconsistent, leading to fragmented implementation, inefficiencies, and potential resistance within organizations. Lecturers emphasize the role of higher education in driving sustainable innovation, advocating for stronger collaboration between maritime industry stakeholders and academic institutions to create structured leadership development programs that integrate epistemology with digital transformation strategies.

A cross-group comparative analysis of respondents highlights notable differences in perspectives on technological innovation and epistemology. Experts tend to focus on practical constraints, emphasizing regulatory pressures, financial feasibility, and operational limitations as key factors influencing technological adoption. Lecturers, in contrast, advocate for structural changes in education and training, arguing that a stronger foundation in epistemological reasoning would lead to more informed and sustainable leadership decisions. Postgraduate students, positioned between academia and industry, express enthusiasm for digital transformation but frustration over the slow adoption of epistemological reasoning in maritime business models. This generational difference suggests that while the future of maritime innovation is likely to be more structured and scientifically grounded, progress will depend on the willingness of industry leaders to embrace change.

A critical implication of these findings is the need for stronger collaboration between academia and industry to bridge the gap between theoretical training and real-world technological implementation. Maritime leadership programs must move beyond traditional business education models and incorporate structured training in epistemology, critical thinking, and scientific reasoning (Kim et al., 2021; Kim & Mallam, 2020). Experts and lecturers agree that competency development in epistemology should not be treated as an abstract concept but as a practical skill essential for leadership and decision-making. By integrating structured epistemological training into maritime education and leadership development programs, industry professionals can ensure that technological innovations are implemented with strategic foresight, long-term sustainability, and scientific rigor.

Another key discussion point is the role of regulatory frameworks in shaping epistemological reasoning in technological adoption. Maritime business operates within a complex regulatory landscape, where compliance with international safety and environmental standards often dictates the pace and scope of technological transformation. This means that while scientific paradigms may support more structured decision-making, external factors such as legal restrictions, environmental policies, and market forces also influence how maritime leaders adopt and implement new technologies. This suggests that epistemological reasoning must be integrated into regulatory frameworks, ensuring that decision-making is based not only on compliance but also on structured, scientific validation of technological choices.

The findings also raise important questions about the future trajectory of epistemology in maritime leadership and innovation. As the industry continues to evolve, will epistemological reasoning become a fundamental component of maritime business decision-making, or will it remain an overlooked aspect of leadership training? The results suggest that while awareness of epistemological frameworks is increasing, structured implementation remains a challenge. Overcoming this challenge will require significant shifts in education, leadership development, and industry-wide perspectives on technological decision-making.

The study's findings reveal that scientific paradigms and epistemological reasoning are crucial but underutilized factors in maritime technological decision-making. While leadership adaptability and structured decision-making play significant roles in ensuring successful technological adoption, barriers such as industry conservatism, regulatory constraints, and lack of epistemological training continue to slow progress. Competency development in epistemology is critical for ensuring that future maritime leaders are equipped with the skills to integrate structured reasoning into their decision-making processes. The sustainability of digital transformation in maritime business will ultimately depend on long-term commitment to epistemological literacy, structured education programs, and industry-wide acceptance of scientific reasoning as a foundational element of technological innovation. Bridging the gap between theory and practice is essential for ensuring that technological advancements in maritime leadership are implemented with clarity, sustainability, and scientific rigor.

Narrative Synthesis and Research Implications

The findings of this study demonstrate that scientific paradigms play a crucial role in shaping technological innovation in maritime leadership. However, the extent to which epistemological reasoning is actively integrated into decision-making remains limited, primarily due to resistance to change, lack of structured training, and the conservative nature of the maritime industry. This research highlights the importance of embedding epistemology into maritime leadership education, ensuring that future industry leaders can critically evaluate and implement technological advancements based on structured philosophical frameworks.

The implications of these findings extend beyond maritime leadership and management. By recognizing the role of epistemology in guiding technological innovation, this study

contributes to the broader discourse on how scientific paradigms influence business decisions in regulated industries. The research suggests that strengthening epistemological literacy in maritime education and professional training programs is essential for ensuring sustainable, data-driven, and strategically sound decision-making in the industry.

This study provides a comprehensive framework for understanding the relationship between epistemology and technological decision-making in maritime leadership. The findings indicate that effective digital transformation requires a paradigm shift—one that acknowledges the philosophical foundations of technological innovation. By integrating structured epistemological training into maritime education, fostering leadership adaptability, and promoting interdisciplinary collaboration, maritime organizations can ensure that technological advancements are implemented with strategic foresight, long-term sustainability, and scientific rigor.

5. Conclusion

This research highlights the crucial role of scientific paradigms in shaping technological decision-making within maritime leadership and management. The findings reveal that leadership adaptability and structured epistemological reasoning are essential for the effective and sustainable integration of technological innovation. Maritime leaders who understand scientific paradigms and structured decision-making processes are more likely to navigate digital transformation successfully, whereas reliance on traditional intuition-based leadership models presents significant challenges to innovation. The study underscores the importance of competency development in epistemology and innovation management, emphasizing that maritime education must evolve to incorporate structured training in scientific reasoning. While there is growing recognition of the need for epistemological literacy, actual implementation remains limited due to industry conservatism, regulatory constraints, and a lack of formalized training programs.

The sustainability of digital transformation in maritime business will depend on the long-term commitment of industry leaders to structured decision-making, ongoing education, and collaborative efforts between academia and industry stakeholders. By bridging the gap between theory and practice, this study provides a framework for enhancing epistemological literacy in maritime leadership, ensuring that future technological advancements are implemented with strategic foresight, long-term sustainability, and scientific rigor. Moving forward, greater integration of epistemology in maritime education and leadership training programs will be essential for equipping industry professionals with the tools necessary to make data-driven, scientifically grounded decisions in a rapidly evolving technological landscape.

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