

Revista Sextante

ISSN : 2665-3923

Vol: 33 No: 01 (2025)

Promoting Scientific Innovation and Interdisciplinary Research in Naval and Maritime Higher Education Institutions

Chinedu Valentin Eriksen

Centre for Maritime Higher Education and Innovation Research, Cape Town, South Africa

Article History

Received Dec, 10th , 2025

Accepted Dec, 11th , 2025

Published Dec, 12th, 2025



© 2025 The Authors. This article is an Open Access article distributed under the terms and conditions of the Creative Commons Attribution(CC-BY)license

<https://creativecommons.org/licenses/by/4.0>

Abstract

Naval and maritime higher education institutions educate the professionals who operate and govern shipping and naval power, and their research must respond to rapid change driven by digitalisation, automation, decarbonisation and strategic competition at sea. These challenges cut across traditional disciplines, yet institutional structures often remain organised around separate departments. This article examines how scientific innovation and interdisciplinary research can be promoted in naval and maritime higher education institutions. Drawing on triple helix and knowledge production theory, research on interdisciplinarity, open innovation and absorptive capacity, and educational research on active learning, it analyses institutional strategy, curriculum, infrastructure, partnerships, faculty incentives and funding. The analysis indicates that innovation is most likely where leadership provides a clear problem-oriented vision, structures and incentives reward collaboration, facilities are shared, partnerships are well managed and evaluation recognises integrative contributions. Limitations are discussed, including disciplinary inertia, security constraints, limited evidence and the risk of collaboration without added value. An illustrative figure summarises expected institutional outcomes under siloed and interdisciplinary orientations.

Keywords: scientific innovation, interdisciplinary research, maritime education, naval institutions, university-industry collaboration

INTRODUCTION

Naval and maritime higher education institutions occupy a distinctive position in the knowledge system. They educate the officers, engineers, naval architects, port managers and policy specialists who operate and govern shipping and naval power, and they conduct research on subjects ranging from hydrodynamics and propulsion to navigation safety, ocean observation, logistics and maritime law. The sector is changing quickly, driven by digitalisation, autonomous vessels, decarbonisation, cyber risk, new energy carriers and the growing strategic importance of the oceans, and these

changes demand research and education that no single discipline can supply. Scientific innovation in this setting increasingly arises at the boundaries between fields. A problem such as the safe operation of a remotely supervised ship, for example, involves control engineering, artificial intelligence, human factors, maritime law, insurance, ethics and training design. Knowledge production has moved from a model dominated by single disciplines toward one organised around problems, in which teams from different fields and organisations work together (Gibbons et al., 1994). Institutions that remain organised around isolated departments risk producing graduates and research that are poorly matched to this reality. This article examines how scientific innovation and interdisciplinary research can be promoted in naval and maritime higher education institutions. It reviews the conceptual foundations of innovation and interdisciplinarity, the distinctive features of the sector, and the roles of institutional strategy, curriculum, infrastructure, partnerships, faculty incentives and funding. It also considers barriers and future directions. The analysis is conceptual and integrative, and the figure presented is an illustrative synthesis rather than a report of new empirical data.

Conceptual Foundations of Scientific Innovation and Interdisciplinarity:

Innovation in higher education is often explained through the interaction of universities, industry and government, described as a triple helix in which each sphere takes on roles traditionally associated with the others (Etzkowitz & Leydesdorff, 2000). Universities move beyond teaching and basic research to contribute to economic and social development, industry engages in knowledge production and training, and governments act as partners and enablers as well as regulators. This model is relevant to maritime institutions, whose research agenda is closely connected to shipping companies, shipyards, ports, navies and regulatory authorities. Interdisciplinarity refers to the integration of information, methods, concepts and theories from two or more disciplines to address problems that lie beyond the scope of any one of them. Klein (1990) distinguishes between multidisciplinary work, in which disciplines contribute side by side, and interdisciplinary work, in which they are integrated, and further identifies transdisciplinary approaches that involve non-academic partners in defining and solving problems. The distinction matters in practice, because many institutional initiatives labelled interdisciplinary remain, in reality, collections of parallel disciplinary efforts. Research on knowledge production supports the case for such integration. Gibbons and colleagues (1994) described a mode of knowledge production that is context-driven, problem-focused and organised in transient, heterogeneous teams, with accountability to a wider range of stakeholders. Evidence from large studies of scientific output shows that teams have become the dominant form of knowledge production, and that team-authored work tends to receive more citations than that of individuals (Wuchty et al., 2007). These findings suggest that institutions seeking innovation should create conditions in which diverse teams can form, work and persist.

Distinctive Role of Naval and Maritime Higher Education Institutions:

Naval and maritime institutions differ from general universities in several important respects. Many are specialised or sector-oriented, with a mission closely tied to a professional field, and some operate within military or governmental structures with their own hierarchy, security requirements and regulatory obligations. Their programmes are often shaped by international conventions on training and certification, and their graduates are expected to meet strict competence standards. This professional orientation provides a strong link to practice but may also encourage a conservative approach to curriculum and research. At the same time, these institutions have unusual strengths for innovation. They possess direct access to operational problems, to ships, ports and naval platforms, and to professionals with extensive practical experience. Their laboratories, training vessels, towing tanks, simulators and sea areas offer opportunities for experimentation that are not available to many general universities. They are also well placed to link education with the research needs of navies and industry, and to translate findings quickly into practice and regulation. The sector faces pressures that make innovation urgent. Digital technology, automation and alternative fuels are changing the competences required of seafarers and engineers, while geopolitical and environmental developments are raising demand for research on maritime security, polar and offshore operations and ocean sustainability. Institutions that rely only on traditional programmes risk falling behind. Promoting innovation and interdisciplinary research is therefore not an optional addition to their mission but a condition of remaining relevant to a rapidly changing sector.

Institutional Strategy, Leadership and Governance:

Innovation and interdisciplinary research flourish when they are supported by institutional strategy and leadership. A clear vision, expressed in strategic plans and supported by resources, signals that crossing disciplinary boundaries is valued rather than merely tolerated. Leaders have a crucial role in articulating priorities, protecting experimental projects from short-term pressures and removing structural barriers. Strategic themes organised around major challenges, such as sustainable shipping, ocean observation, maritime security or digital navigation, give researchers from different fields a common focus. Organisational structure also matters. Traditional departmental structures concentrate budgets, appointments and promotion within disciplines, which can discourage collaboration. Institutions can address this by creating research centres, institutes or platforms that bring together staff from several departments, by using matrix arrangements that allow joint appointments and shared supervision, and by designing governance

bodies that include representatives of different fields as well as external partners. A national review of interdisciplinary research emphasised that institutional structures and policies can either facilitate or obstruct such work (National Academies, 2005). Governance in naval institutions may need to balance openness with security and hierarchy. Rules on classified research, data protection and chain of command can complicate collaboration with civilian partners and international colleagues. Clear policies that define what can be shared, how intellectual property is managed and how partners are engaged can reduce uncertainty. A governance approach that is transparent, adaptive and attentive to risk allows institutions to benefit from collaboration while meeting their obligations to the state and to the public.

Curriculum Design and Interdisciplinary Pedagogy:

Education is a primary channel through which innovation capacity is built. Curricula that treat technical, operational, legal, environmental and human dimensions of maritime activity as separate subjects may leave students unable to integrate them in practice. Interdisciplinary curricula use integrated modules, capstone projects, shared courses across programmes and problem-based learning to develop the capacity to work with colleagues from other fields. Examples include joint projects in which nautical, engineering and logistics students design a port operation or a ship system together. Active and collaborative learning strategies are central to this approach. A broad review of the engineering education literature concludes that active learning, collaborative learning and problem-based learning are supported by evidence as effective ways to improve learning outcomes compared with traditional lecturing alone (Prince, 2004). These methods are well suited to maritime education, where simulation, case studies, laboratory work and project work are already familiar. Integrating them across disciplines expands the range of perspectives that students encounter and strengthens their problem-solving skills. Research education should also be interdisciplinary. Postgraduate and doctoral programmes can include shared methodology courses, co-supervision by staff from different fields, rotations in industry or navy settings and opportunities to present to non-specialist audiences. Assessment needs to reflect interdisciplinary goals, evaluating the quality of integration and teamwork as well as disciplinary knowledge. Students who experience this approach are more likely to carry it into their careers as officers, engineers, researchers and policymakers.

Research Infrastructure, Laboratories and Simulation Facilities:

Infrastructure strongly shapes the possibilities for collaborative research. Shared facilities such as hydrodynamic laboratories, bridge and engine-room simulators, cyber ranges, materials laboratories, ocean observation platforms and research vessels can serve as common spaces where researchers from different disciplines meet and work on joint problems. Institutions that treat major facilities as open institutional resources, rather than as the property of single departments, create more opportunities for cross-disciplinary projects and for efficient use of expensive equipment. Digital infrastructure is increasingly important. High-performance computing, digital twins of ships and ports, shared data repositories and tools for modelling and visualisation allow researchers from different backgrounds to work with common representations of complex systems. Simulation environments are especially valuable because they can combine technical models with human behaviour, regulation and operational procedures, allowing the testing of new technologies and concepts in a safe environment before they are deployed at sea. Physical and virtual spaces should be designed to encourage interaction. Innovation hubs, co-located laboratories, seminar spaces and virtual collaboration platforms help researchers to meet informally and to build trust. Technical staff who support the operation of facilities are vital partners and should be recognised as contributors to research. Investment decisions should take account of long-term maintenance, access policies and training, since facilities that are underused or poorly supported yield little innovation.

Partnerships with Industry, Navies and Government:

External partnerships are among the most powerful drivers of innovation in maritime institutions. Collaboration with shipping companies, shipyards, equipment manufacturers, ports, classification societies, navies and regulators gives researchers access to real problems, data and testing opportunities, and gives partners access to expertise and talent. Open innovation, in which organisations use external as well as internal ideas and pathways to market, offers a useful framework for understanding such exchanges (Chesbrough, 2003). The ability of an institution to benefit from external knowledge depends on its absorptive capacity, meaning its ability to recognise the value of new information, assimilate it and apply it (Cohen & Levinthal, 1990). Institutions build this capacity through prior related knowledge, skilled staff, internal communication across units and sustained engagement with partners. Research on university-industry relations shows that academic engagement takes many forms, including collaborative research, contract research, consulting and informal networks, and not only formal commercialisation (Perkmann et al., 2013). Partnerships require careful management. Differences in time horizons, expectations about publication, confidentiality, and ownership of intellectual property can generate tension, and naval partners may impose security restrictions. Effective arrangements define objectives and responsibilities early, agree on rules for data and intellectual property, and keep academic freedom and integrity intact. International partnerships with other maritime universities, research institutes and organisations are also valuable, especially for institutions in developing regions, because they extend networks, resources and perspectives.

Faculty Development, Incentives and Research Culture:

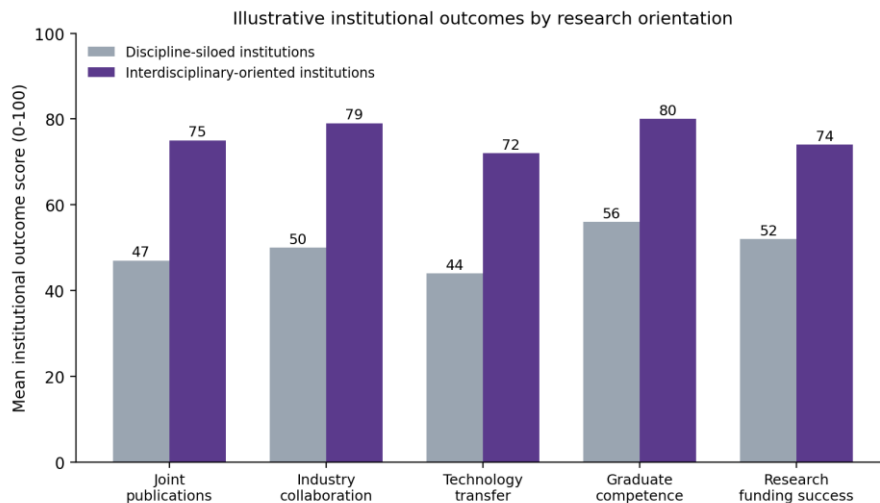
Faculty members are the central actors in innovation, and their behaviour is shaped by incentives and culture. In many institutions, promotion and recognition depend on disciplinary publications, which can deter staff from investing time in interdisciplinary or applied projects that take longer and are harder to publish in established journals. A critical assessment of the field notes that interdisciplinary work faces structural obstacles in hiring, evaluation and funding systems that remain organised around disciplines (Jacobs & Frickel, 2009). Institutions can respond by revising promotion criteria to recognise team science, joint supervision, industry collaboration, technology transfer and public engagement, by offering seed funding and time release for collaborative projects, and by providing training in teamwork, communication across disciplines and project management. Mentoring and communities of practice help staff to learn the vocabulary and methods of other fields. Particular attention should be given to early-career researchers, who may be especially vulnerable to the risks of working across boundaries. Culture determines whether collaboration is productive. Research on team learning has shown that psychological safety, a shared belief that it is safe to take interpersonal risks, supports learning behaviour such as asking questions, admitting errors and seeking feedback (Edmondson, 1999). In hierarchical naval and maritime settings, where deference to rank is strong, building such an environment requires deliberate effort. Leaders who welcome challenge, share credit and treat disagreement as a source of learning help to establish a culture in which interdisciplinary teams can thrive.

Funding, Evaluation and Measurement of Impact:

Funding arrangements strongly influence whether innovation and interdisciplinary research occur. Competitive grants allocated through disciplinary panels may disadvantage proposals that span fields, while short project cycles may be insufficient for the development of integrated approaches. Institutions can create internal funds for pilot interdisciplinary projects, pursue large mission-oriented programmes with governments, navies and industry, and seek international funding that explicitly supports collaboration. Diversifying funding sources also reduces dependence on any single sponsor. Evaluation must be designed to match the aims of interdisciplinary work. Conventional indicators such as journal rankings and citation counts capture only part of the value of research and may undervalue integrative and applied contributions. A broader set of indicators could include collaboration across fields and organisations, joint publications, patents and technology transfer, contributions to standards and regulation, influence on practice, graduate competence and the development of research capacity. The use of qualitative evidence, such as case studies and stakeholder assessments, adds depth to quantitative measures.

Challenges, Limitations and Future Directions:

Several challenges limit the promotion of innovation and interdisciplinary research in naval and maritime institutions. Disciplinary traditions, departmental budgets and promotion systems create inertia, and the language, methods and standards of different fields can impede communication. Limited funding, heavy teaching loads, security restrictions and the narrow professional orientation of some programmes add further constraints. Interdisciplinary teams may also suffer from unclear leadership, unequal status among disciplines and difficulty in publishing integrated results. There are also conceptual and empirical limitations. Interdisciplinarity is not valuable in itself, and poorly designed collaboration can consume resources without delivering insight. Evidence on the effects of interdisciplinary initiatives in specialised maritime institutions is limited and often based on single cases or perceptions, so that causal claims should be made cautiously. Institutions should therefore pursue interdisciplinary work where it fits the problem, and evaluate initiatives critically rather than assuming that they will succeed. Future directions include the development of problem-oriented research platforms for major maritime challenges, closer integration of research with simulation-based and experiential education, stronger international networks among maritime universities, and the use of digital tools to share data and models. Greater attention should be given to ethics, security and responsible innovation, particularly in areas such as autonomous systems and artificial intelligence. Comparative and longitudinal studies that follow institutions over time would improve understanding of which strategies best promote innovation in this important sector.



Summary:

Promoting scientific innovation and interdisciplinary research in naval and maritime higher education institutions requires coordinated action across strategy, structure, education, infrastructure, partnerships and culture. The reviewed literature indicates that problem-oriented leadership, flexible organisational structures, integrated curricula based on active learning, shared laboratories and simulation facilities, well-managed collaboration with industry, navies and government, and incentives that reward team-based work together create conditions in which innovation can develop. Absorptive capacity and a psychologically safe research culture help institutions to use external knowledge and to learn from disagreement. These approaches have limits. Disciplinary inertia, security restrictions, funding constraints and weak evaluation systems can undermine them, and interdisciplinarity should be pursued only where it adds value to the problem at hand. Future work should prioritise comparative and longitudinal evidence, problem-oriented research platforms, international cooperation and responsible innovation in areas such as autonomy and artificial intelligence, so that maritime institutions can prepare graduates and generate knowledge suited to a changing ocean sector.

References:

- Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.
- Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128–152.
- Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, 44(2), 350–383.
- Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and Mode 2 to a Triple Helix of university–industry–government relations. *Research Policy*, 29(2), 109–123.
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. SAGE.
- Jacobs, J. A., & Frickel, S. (2009). Interdisciplinarity: A critical assessment. *Annual Review of Sociology*, 35, 43–65.
- Klein, J. T. (1990). *Interdisciplinarity: History, theory, and practice*. Wayne State University Press.
- National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2005). *Facilitating interdisciplinary research*. National Academies Press.
- Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., et al. (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy*, 42(2), 423–442.
- Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, 93(3), 223–231.
- Nowotny, H., Scott, P., & Gibbons, M. (2001). *Re-thinking science: Knowledge and the public in an age of uncertainty*. Polity Press.
- Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science*, 316(5827), 1036–1039.