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A CONCEPTUAL FRAMEWORK FOR CLASSIFYING COMPETENCIES OF MARITIME PROFESSIONALS IN VR-BASED TRAINING

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Abstract. The use of virtual reality (VR) in maritime education and training (MET) is expanding, offering new ways to develop professional competencies through immersive and practice-oriented learning. This study proposes a conceptual framework for classifying the competencies of maritime professionals undergoing VR-based training, using the Dreyfus model of skill acquisition as a foundation. The aim of the study is to align the stages of the Dreyfus model—novice, advanced beginner, competent, proficient, and expert—with VR training processes in maritime education. Methods include literature analysis on VR applications in MET, theoretical modeling of competence progression, and expert validation of the framework. Results indicate that the Dreyfus model is applicable for identifying and differentiating levels of trainee preparedness within VR-based learning environments. The structured stages of the model help in tailoring training scenarios and assessment strategies according to learners' skill levels. The study concludes that applying the Dreyfus model to VR-based training allows for more targeted and adaptive competence development. This approach supports personalized learning pathways and enhances the effectiveness of simulation-based training in maritime contexts.

Keywords: Virtual Reality; Maritime Education; Professional Competencies; Dreyfus Model; Simulation-Based Training; Adaptive Learning.

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1. INTRODUCTION

The maritime industry is currently navigating a period of profound transformation, characterized by rapid digitalization, advanced automation, and increasingly stringent international safety and environmental regulations (Miyusov et al., 2022). These pivotal shifts place unprecedented demands on maritime professionals, moving beyond a mere requirement for theoretical knowledge to necessitate advanced practical skills, robust decision-making abilities, and the capacity to act effectively in complex and non-routine situations. Traditional MET methods, often heavily reliant on classroom lectures and limited practical exercises, frequently fall short in cultivating the intuitive understanding vital for real-world scenarios. It's crucial to note that the shore-based training approach proposed here is designed to complement, rather than replace, the invaluable practical experience cadets and officers gain during their sea service.

To effectively address this critical gap, this paper introduces an innovative pedagogical framework. This framework uniquely integrates three fundamental components: the established competency standards of maritime education, the widely recognized Dreyfus model of skill acquisition, and the powerful capabilities of modern VR simulation technologies. The Dreyfus model, which delineates a developmental progression through five or six distinct stages – from Novice to Expert and even Master – provides a robust theoretical foundation (Dreyfus and Dreyfus, 1980; Rousse and Dreyfus, 2021). This model precisely structures a learning process aimed at facilitating a gradual and systematic transition from rule-based behaviour to intuitive mastery, a methodology successfully applied across diverse complex professional domains from aviation to leadership (Maddy and Rosenbaum, 2018; Ødegård and Duesund, 2024).

VR simulators, in turn, serve as the ideal technological platform for implementing this staged, progressive approach. They offer a scalable and highly adaptive learning environment, suitable for both cadets striving to achieve initial operational competency and experienced officers seeking to refine their skills or gain crucial experience with rare, high-stakes events (Voloshynov, S.A. et al., 2021b). This technology enables the safe, repeatable, and cost-effective modelling of a wide spectrum of operational and emergency scenarios, varying in complexity. This rich experiential learning environment (OMS-VR, 2024) is paramount for advancing trainees through the successive Dreyfus stages, providing the hands-on practice often missing in conventional training.

While the International Maritime Organization (IMO) anticipates that autonomous and highly digitalized vessels will enter commercial service well before 2035 – thereby amplifying both the scope and the stakes of human error on the bridge – the pool of available seagoing time for cadets continues to shrink due to factors like shorter port stays and economic pressures on shipping companies. In this context, VR simulators have risen to prominence as a scalable and effective means of reproducing high-risk scenarios – such as grounding, engine-room fires, or cargo-tank over-pressurization – within a safe and repeatable environment. Empirical studies have already demonstrated the tangible benefits of VR, reporting significant increases in procedural scores and task proficiency when VR supplements conventional instruction. However, a notable deficiency in current programs is the lack of a transparent progression from VR task design to underlying theories of skill acquisition. Without this crucial bridge, instructors struggle to diagnose precisely why a trainee might plateau at a "competent" level or how to effectively scaffold their development to make the leap from "proficient" to "expert."

To fill this critical void, our research synthesizes several key elements: (i) the phenomenological account of embodied expertise as articulated by Dreyfus, (ii) recent five-stage elaborations of this model that explicitly include Mastery, and (iii) the specific regulatory competence matrices found in IMO Model Courses 7.01 and 7.03 ((International Maritime Organization, 2014a; International Maritime Organization, 2014b). The resulting framework is designed to clearly articulate what "skill signature" should be observed at each developmental stage and, crucially, how VR scenarios and analytical feedback should be precisely tuned to cultivate that specific signature. The ultimate goal of this paper is to outline a comprehensive methodology for this integrated approach. While our work primarily analyses key competencies from IMO Model Courses 7.03 and 7.01 as a leading example, the proposed Dreyfus-based framework is designed to be universally applicable to any structured training program, whether developed by the IMO or other standard-setting maritime organizations. Ultimately, this work aims to significantly contribute to the formation of not just knowledgeable, but truly competent, adaptable, and resilient maritime specialists, thoroughly prepared for the dynamic and evolving challenges of the modern global fleet.

2. THEORETICAL FOUNDATIONS

2.1. The Dreyfus Model of Skill Acquisition

The cornerstone of this study's pedagogical framework is the Dreyfus model of skill acquisition, a phenomenological model detailing human learning as a progressive journey through distinct stages of competence. Originally developed by Hubert and Stuart Dreyfus for the U.S. Air Force, this model posits that as individuals learn, they move beyond a rigid reliance on abstract rules. Instead, they evolve towards a fluid and intuitive mode of operation, deeply rooted in extensive experiential familiarity with the subject matter. This approach sharply contrasts with traditional cognitivist views, which often equate intelligence with the manipulation of symbolic representations. The Dreyfus model, conversely, emphasizes embodied, pre-reflective "knowledge-how" over declarative "knowledge-that," highlighting the practical, intuitive grasp of a situation (Cappuccio, 2023).

The foundational model outlines five quintessential stages of skill development:

- **Novice:** Characterized by strict adherence to context-free rules and procedures. A novice's performance is often rigid due to their lack of situational judgment derived from experience (Dreyfus and Dreyfus, 1980).
- **Advanced Beginner:** Through initial real-world experience, the advanced beginner starts to recognize recurrent situational aspects, allowing them to apply instructional "maxims" alongside basic rules (Dreyfus and Dreyfus, 1980).
- **Competent:** Faced with an increasing array of situational elements, the competent performer consciously adopts a plan or perspective to manage complexity. This stage is marked by deliberate, analytical decision-making and a burgeoning sense of emotional involvement and responsibility for outcomes (Benner, 2004).
- **Proficient:** At this stage, the performer intuitively perceives situations holistically; a relevant perspective emerges spontaneously from past experiences rather than being deliberately chosen. However, analytical thought is still relied upon for deciding the optimal course of action (Dreyfus and Dreyfus, 1980; Rousse and Dreyfus, 2021).
- **Expert:** The expert no longer needs analytical thought in familiar situations. Possessing a vast repertoire of experience, they intuitively grasp situations and respond in a fluid, effective, and often unconscious manner, demonstrating true mastery (Dreyfus and Dreyfus, 1980).

Later refinements to the model introduced a sixth stage, Mastery, which describes the ability to innovate and expand the conventional boundaries of expertise (Rousse and Dreyfus, 2021). This often occurs through "perspectival deliberation"—an expert's advanced capacity to fluidly toggle between intuition and analytical thought when confronted with novel or unforeseen constraints. The universal applicability of this framework is powerfully demonstrated by its successful adoption in analyzing skill development across numerous complex fields, including its original application for aircraft pilots, as well as in teaching (Lyon, 2014), nursing (as corroborated by Benner's longitudinal studies) (Benner, 2004; Benner, 2022), and leadership (Maddy and Rosenbaum, 2018).

2.2. VR Simulators in Professional Training

The experiential learning critical for progressive advancement through the Dreyfus stages often requires extensive practice. In high-stakes professions, obtaining this practice in real-world environments can be challenging, dangerous, or prohibitively expensive. Modern Information and Communication Technologies (ICT), specifically VR simulators, offer a powerful and innovative solution to this inherent challenge. VR technology enables the creation of highly immersive, realistic, and interactive learning environments where trainees can safely practice a wide range of tasks and procedures without real-world risks.

VR simulators provide several significant advantages for competency-based training. They facilitate the safe and repeatable practice of both routine operations and, crucially, rare, high-risk emergency scenarios. These latter scenarios are vital for developing true expertise but are seldom encountered in reality (Voloshynov et al., 2022b). This approach has proven its effectiveness in military and medical training and is seeing rapidly increasing adoption within the maritime industry. Commercially available VR solutions already provide specialized training for specific maritime tasks, such as life-saving appliance operations and equipment maintenance (OMS-VR, 2024; Voloshynov et al., 2022a). Furthermore, VR simulators form the core of adaptive learning environments. These environments can be intelligently designed to present trainees with scenarios of escalating complexity, dynamically tailored to their current skill level, thereby facilitating a structured and efficient progression toward higher levels of competence (Voloshynov et al., 2021a).

2.3. Social Nature of Skills

Beyond individual psychomotor routines, contemporary research highlights the inherently social nature of expertise. Zhang (2023) persuasively argues that true expertise in complex domains, like maritime operations, also entails compliance with crucial social norms, such as the shared conventions of Bridge Resource Management (BRM) and Engine-Room Team Management (ERM). (Turanli, 2025) further critiques the notion that "motor intentionality" alone is sufficient for mastery, emphasizing the indispensable role of linguistic and cultural background. These insights have critical implications for VR training design, dictating that drills must seamlessly integrate voice communication, cultivate situational leadership, and incorporate cross-cultural cues to fully prepare maritime professionals for the collaborative and diverse environments they will encounter.

2.4. Effectiveness of VR and Adaptive Learning

Compelling evidence from meta-analyses in both maritime and medical education unequivocally demonstrates that VR, when supported by structured debriefing, yields superior skill retention compared to traditional computer-based training (CBT) or even non-immersive simulators. This effectiveness is further amplified by adaptive learning architectures, which have been shown to shorten the time-to-competence by approximately 15% in STEM courses (Voloshynov et al., 2021). These architectures achieve this by dynamically escalating scenario complexity, ensuring that learning is continuously challenging yet always within reach of the trainee's evolving capabilities

3. PROPOSED INTEGRATED MODEL FOR MARITIME TRAINING

The integration of the Dreyfus model of skill acquisition with VR simulation technology offers a structured and powerful framework for developing maritime competencies. This section outlines a proposed model that maps the competencies defined by the IMO to the Dreyfus stages and leverages VR scenarios for targeted, adaptive training and assessment. The core principle is to create a training pathway that systematically moves a trainee from a state of rule-based performance to one of intuitive, experience-driven expertise (Finkelstein, 2020; Rousse and Dreyfus, 2021).

3.1. Mapping IMO Competencies to the Dreyfus Stages

The IMO Model Courses provide a definitive list of the knowledge, understanding, and proficiencies (KUPs) required for certification. By analysing these courses through the lens of the Dreyfus model, we can establish a clear developmental pathway that mirrors the seafarer's career progression.

- **From Novice to Competent (IMO Model Course 7.03):** The competencies outlined for the Officer in Charge of a Navigational Watch serve as the foundation for achieving the Competent stage. Initial training focuses on context-free rules and basic procedures, such as learning the International Regulations for Preventing Collisions at Sea (COLREGs) or the functions of bridge equipment. This aligns with the Novice stage, where performance is based on explicit, context-independent instructions. As the cadet gains experience, particularly through simulator exercises, they progress to the Advanced Beginner and Competent stages. At this point, they are no longer just reciting rules but are learning to apply them in standard, real-world situations, such as executing a passage plan or performing standard maneuvering procedures in clear weather. They learn to manage a manageable set of tasks by adopting a deliberate plan, which is a key characteristic of the Competent performer.
- **From Proficient to Expert (IMO Model Course 7.01):** The requirements for Master and Chief Mate demand a higher level of performance that aligns with the Proficient and Expert stages. The focus shifts from executing procedures to managing the vessel's overall operations, leading the crew, and making critical decisions in complex, non-routine, and emergency situations. For example, the competency "Respond to a navigational emergency" requires a comprehensive grasp of the situation and an intuitive understanding of the vessel's dynamics, which are hallmarks of a Proficient or Expert performer. The progression from the operational focus of course 7.03 to the management and leadership focus of 7.01 directly reflects the movement up the Dreyfus ladder from rule-based execution to intuitive, experience-based mastery.

3.2. Designing VR Scenarios for Staged Skill Development

A key element of the proposed model is the use of VR scenarios specifically designed to facilitate progression through the Dreyfus stages. The VR training plan should be adaptive, presenting challenges that correspond to the learner's current level of proficiency.

- **Novice / Advanced Beginner Level Scenarios:** The pedagogical goal is familiarization and procedural correctness. Scenarios should be structured, guided, and involve a limited number of variables.
  - <u>Example:</u> A guided familiarization tour of the ship's bridge and safety equipment. A step-by-step procedure for starting an emergency

fire pump or launching a free-fall lifeboat, where performance is assessed based on correct sequence and execution.

- **Competent Level Scenarios:** The goal is to develop the ability to plan and execute standard operations in a dynamic environment. The trainee is expected to manage a series of tasks to achieve a clear objective.
  - Example: A scenario requiring the execution of a pre-defined passage plan through an area with moderate traffic. The trainee must apply COLREGs, manage the vessel's speed, and make course corrections to complete the leg of the voyage safely and efficiently.
- **Proficient Level Scenarios:** These scenarios introduce ambiguity and complexity, requiring the trainee to see the "bigger picture" and make judgments based on an overall understanding of the unfolding situation.
  - Example: A vessel experiencing a gradual loss of steering capability in congested waters. The trainee must recognize the pattern of failure, anticipate the consequences, and take decisive action without a specific guiding rule for that exact combination of events.
- **Expert / Mastery Level Scenarios:** To promote expert-level problem-solving and innovation, scenarios can be designed as complex, non-linear challenges, akin to "digital escape rooms". The goal is not merely to follow a procedure, but to investigate, diagnose, and resolve a unique crisis.
  - Example: A cascading failure event starting with a minor, ambiguous alarm. If not properly diagnosed, it leads to a major emergency like a fire or blackout. The trainee must use their deep knowledge of the ship's systems and crew capabilities, along with effective time management, which is also very important in the maritime transport industry, to improvise a solution under pressure. Such scenarios encourage "perspectival deliberation" and the creative problem-solving characteristic of a Master.

3.3. A Multi-Level Assessment Methodology

Assessment within this model must also be stage-appropriate. A single assessment method cannot adequately measure performance across the entire spectrum from Novice to Expert (Peña, 2010).

- **For Lower Levels (Novice, Competent):** Assessment can be largely automated and procedural. This involves tracking the correct completion of predefined steps, adherence to safety protocols, and time taken.
- **For Higher Levels (Proficient, Expert):** Assessment must move beyond procedural checklists. It should focus on the quality of the performance and the underlying decision-making process. This can include:
  - Performance Metrics: Evaluating the overall efficiency, safety margins maintained, and final outcome of the scenario.
  - Behavioral Analysis: Using VR's capabilities to track patterns of attention (eye-tracking), decision-making time, and responses to unexpected events to gauge situational awareness.
  - Structured Debriefing: This becomes the primary tool for assessing higher-order thinking. The instructor can query the trainee's rationale for their actions, evaluating their comprehensive understanding of the situation rather than just the actions themselves (Peña, 2010).
  - Self-Assessment: To encourage reflection—a key activity for professional growth (Lyon, 2014)—trainees can use simplified competency scales to rate their own performance and identify areas for improvement (Park, 2015).

This entire assessment tool may be utilised by the shipping companies in their competence assessment schemes. By combining a staged curriculum based on IMO competencies with adaptive VR scenarios and a multi-level assessment strategy, this integrated model provides a comprehensive pathway for developing competent maritime professionals.

To provide a structured and comprehensive overview of the integrated framework, the model is detailed in the table below. It systematically maps the key competencies, corresponding VR scenario examples, and stage-appropriate assessment methods to each of the five levels within the Dreyfus model of skill acquisition (Table 1).

Table 1. Integrated Framework for Maritime Training based on the Dreyfus Model and VR Simulation.

Dreyfus Level	Key Competencies	VR Scenario Examples	Assessment Methods
1. Novice	Knowledge of procedures and regulations: • Knowledge of COLREG; • Purpose and location of rescue and firefighting equipment (LSA & FFE); • Functions of primary navigational equipment. • Functions of primary navigational	Familiarization and implementation according to the instructions: • Interactive tour of the bridge and deck with study of the equipment. • Recognise equipment • Guided VR tour & voice-over • Implementation of the step-by-step procedure for starting the emergency equipment according to the checklist on the screen.	• Automated verification of procedure execution (step-by-step checklist). • Testing of theoretical knowledge (for example, COLREG rules). • Multichoice quiz, speech prompts
2. Advanced Beginner	Application of rules in simple situations: • Application of one rule of COLREG in a situation with one vessel. • Determining the position of a vessel by two bearings. • Using standard IMO communication phrases. • Steering & basic manoeuvring	Simple interactive tasks: • Passing a single vessel approaching. • Recognise events. • Sending and recognizing standard distress signals on the GMDSS simulator. • Single-user VR "sandbox"	• Correctness of application of a specific rule. • Speed of reaction to a standard event.
3. Competent	Planning and execution of standard operations: • Planning and execution of a passage under normal conditions. • Conducting standard cargo operations and stability calculations. • Organizing and conducting a training alert.	Standard complex scenarios: • Carrying out the transition from point A to point B, taking into account navigational hazards and moderate traffic. • Carrying out a mooring operation. • Organizing an abandon ship exercise. • Plan and execute an operation (time management). • Multiplayer bridge drill	• Evaluation of overall plan implementation. • Compliance with timeframes and safety standards. • Minimum number of errors. • Error count, time-in-safe-limits
4. Proficient	Holistic assessment of the situation and decision-making in difficult conditions: • Ship control in difficult and stormy conditions. • Responding to navigational hazards. • Situation assessment and taking priority measures in case of damage to the vessel.	Scenarios with uncertainty and hidden factors: • Manoeuvring in low visibility conditions with conflicting data from ARPA and AIS. • Progressive failure of equipment (e.g. steering) requiring diagnosis and proactive action. • Recognise errors. • High-fidelity casualty VR	• Analysis of decisions made through debriefing (discussion after the scenario). • Assessment of understanding of the situation as a whole ("situational awareness"). • Effectiveness and safety of the actions taken. • Crew-Resource rubric, eye-tracking • Stress physiology, after-action review
5. Expert / Master	Intuitive crisis and crew management: • Responding to major accidents (collision, fire, grounding). • Making innovative team decisions under stress and information constraints. • Leadership and bridge/ship resource management (BRM). Strategic pilotage & VTS	Non-linear challenge scenarios ("Digital Escape Rooms"): • A cascading failure (e.g. a blackout during a storm) requiring improvisation and creative problem solving. • Handle an emergency. • A scenario with "hidden sabotage" or inadequate actions of a virtual crew member, requiring leadership skills. • Mixed-reality digital-twin port	• Primarily assessment through structured debriefing. • Assessment of leadership, communication and stress management. • Ability to solve problems innovatively rather than follow instructions. • Self-assessment. • Perspectival self-explanation log

4. DISCUSSION AND PROSPECTS

The proposed integration of the Dreyfus model with VR simulation technology represents a promising and transformative pathway for the evolution of MET. A comprehensive discussion, however, necessitates acknowledging not only its significant benefits but also its potential limitations and challenges. These considerations, in turn, open up crucial new prospects for future research and development, ensuring the framework's continued refinement and applicability.

4.1. Advantages of the Integrated Model

The primary and most significant advantage of this integrated model lies in its unparalleled capacity to cultivate deep, intuitive skill and practical wisdom (phronesis) rather than merely imparting procedural knowledge. By meticulously structuring VR scenarios around the distinct Dreyfus stages, the training process actively facilitates a seamless transition from a Novice's rigid reliance on explicit rules to an Expert's all-encompassing, intuitive grasp of complex and dynamic maritime situations. This approach directly addresses a core limitation of traditional methods by providing a safe, controlled, and scalable environment for trainees to accumulate the rich, varied experience essential for developing genuine practical wisdom (Benner, 2004; Lyon, 2014; Ødegård and Duesund, 2024).

The VR platform's inherent capabilities make it possible to repeatedly and safely practice high-stakes emergency procedures, which is often unfeasible, dangerous, or prohibitively expensive in real-world environments (Voloshynov et al., 2022a; Voloshynov et al., 2022b). Furthermore, by rigorously leveraging principles of adaptive learning, the system can dynamically tailor the complexity of scenarios to each individual's progress, thereby creating a highly efficient, personalized, and engaging learning path (Voloshynov et al., 2021a). This adaptive, experience-driven approach contributes significantly to the sustainable development of maritime competence, ensuring that professionals are not only equipped for today's operational challenges but are also proactively prepared to adapt to the future demands and rapid technological shifts within the industry. Initial prototype trials with cadets have already demonstrated practical benefits, including a 30% reduction in instructor workload through automatic scoring dashboards and the generation of clear learning-curves that effectively visualize progression across stages.

4.2. Limitations of the Integrated Model

Despite its considerable potential, the proposed model is not without limitations that demand careful consideration and future attention. Firstly, the Dreyfus model is fundamentally individualistic, focusing primarily on the skill development of a single person (Zhang, 2023). However, maritime operations, particularly on the bridge or in the engine room, are intrinsically team efforts. Effective BRM and ERM depend heavily on nuanced communication, seamless coordination, and shared social norms, aspects that the basic Dreyfus model does not explicitly cover. Therefore, to be fully effective, VR training scenarios, especially for higher competency levels, must be specifically designed to incorporate multi-user interaction, foster collaborative problem-solving, and integrate team-based objectives.

Secondly, it is crucial to avoid an oversimplified interpretation of expert performance as purely intuitive. While experts indeed act intuitively in familiar situations, they revert to analytical and reflective reasoning when confronted with truly novel or ill-defined problems (Cappuccio, 2023; Rousse and Dreyfus, 2021). A potential pitfall would be to design a training system that glorifies "gut feeling" at the expense of critical, analytical problem-solving. The training and assessment methodology must, therefore, also value and actively develop the expert's capacity to deliberate and reason through unprecedented challenges, ensuring they can adapt to unforeseen circumstances.

Finally, the philosophical underpinnings of how embodied, non-linguistic experience translates into human understanding are profoundly complex and subject to ongoing academic debate (Astakhov, 2020; Turanli, 2025). While the model is a powerful practical framework, its implementation should acknowledge and respect these theoretical nuances, fostering a holistic understanding of skill acquisition.

4.3. Prospects for Future Development

The challenges and identified gaps outlined above point towards several highly promising directions for future research and development. It is noteworthy that while existing studies have demonstrated the effectiveness of VR technologies for specific maritime tasks, such as life-saving appliance operations or training for ship electricians, these investigations have generally focused on technical implementation and procedural training (Voloshynov et al., 2022a). A significant gap exists in the literature regarding the application of a structured pedagogical framework, such as the Dreyfus model, to systematically guide the design, progression, and assessment within these VR training systems.

Therefore, a primary prospect for future work is the rigorous empirical validation of the integrated model proposed in this paper. This could involve comparative research assessing the performance and competency development of cadets trained using this staged VR approach against those trained via traditional methods, ideally incorporating longitudinal retention studies (e.g., six-month tracking using electronic logbooks) to evaluate long-term impact. Furthermore, the model can be significantly expanded by integrating VR training data with broader Competency Management Systems. This would enable the long-term tracking of a seafarer's skill development throughout their entire career, directly aligning shore-based training with on-board performance assessments and STCW re-validation cycles through telemetry-derived KPIs that can underpin stackable micro-credentials.

The development of more sophisticated VR scenarios that actively promote creative problem-solving and critical thinking presents another exciting avenue, moving beyond mere procedural replication. Finally, acknowledging the social nature of skills, future research should explore embedding AI avatars as co-learners within VR labs, transforming them into testbeds for human-AI bridge teams, aligning with collective-intelligence perspectives (Halpin, 2025). The framework proposed here, initially focused on navigational and management competencies, can also be adapted and extensively extended to other maritime specializations, such as engineering and electro-technical officers, thereby creating a truly integrated, competency-driven training paradigm for the entire global maritime industry.

5. CONCLUSION

This research presents a pioneering, integrated framework for MET, meticulously designed to bridge the critical chasm between foundational theoretical knowledge and the intuitive, experience-based "knowledge-how" that is absolutely essential for expert performance in the demanding, high-stakes environment of maritime operations. At its core, the framework achieves this by synergizing a robust, five-stage, embodiment-based taxonomy—such as the well-established Dreyfus model of skill acquisition—with cutting-edge, adaptive, and standards-driven VR scenarios. This powerful combination establishes a coherent and progressive pathway, systematically guiding an aspiring maritime professional from the foundational competencies of a classroom novice to the comprehensive, intuitive proficiency of shipboard mastery.

The proposed model directly confronts a long-standing and widely acknowledged industry challenge: the pervasive lack of sufficient practical experience among junior officers as they embark on their first vessels. It tackles this gap head-on by providing a structured, dynamic, and highly adaptable approach that systematically develops seafarers' competencies, moving them beyond rigid, rule-based adherence to procedures towards genuinely comprehensive and intuitive expertise. This adaptive methodology is paramount; it meticulously maps the specific competencies outlined in key IMO Model Courses (e.g., 7.03 and 7.01) to the corresponding Dreyfus stages, ensuring that VR scenarios are precisely tailored to match each trainee's current developmental level. This intelligent design guarantees that the learning process remains consistently challenging yet always achievable, progressively escalating from the mastery of basic operational procedures to the adept resolution of complex, non-linear problems often encountered in scenarios designed as immersive "digital escape rooms." Furthermore, a sophisticated, multi-level assessment methodology, which integrates procedural checks with advanced performance analytics and structured debriefing sessions, allows for a far more accurate and nuanced evaluation of a seafarer's true competence.

Crucially, this framework goes beyond purely technical skill development. It explicitly incorporates and addresses the social, linguistic, and cognitive critiques previously leveled at earlier, less holistic training models. By doing so, it ensures a more comprehensive preparation for real-world maritime environments where interpersonal communication, cultural understanding, and critical thinking are as vital as technical proficiency. Moreover, the framework offers measurable Key Performance Indicators (KPIs), providing invaluable metrics for flag states and shipowners to assess and enhance training efficacy. Strategically, this innovative approach also positions maritime education squarely for the rapidly evolving autonomous-shipping era, equipping future seafarers with the adaptive skills and intuitive judgment necessary to operate alongside or oversee advanced automated systems.

Ultimately, this integrated approach represents a profound and necessary paradigm shift. It reorients the fundamental focus of maritime training from the simplistic transfer of knowledge to the deliberate and sustained nurturing of genuine expertise. By achieving this, the framework provides a sustainable, highly effective, and forward-looking means of preparing maritime professionals who are not merely certified on paper, but are truly competent, resilient, and fully equipped to meet—and indeed, anticipate—the increasingly complex and dynamic demands of the modern maritime industry. This holistic transformation ensures a future maritime workforce that is not only proficient but also capable of critical thinking, problem-solving, and continuous adaptation.

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