

The Efficacy of Immersive Virtual Reality (VR) in Enhancing Maritime Navigational Competencies: A Systematic Review

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ABSTRACT

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Immersive virtual reality (VR) is increasingly proposed as a supplement to full-mission bridge simulators and conventional shipboard instruction for developing navigational competencies among maritime cadets and seafarers, yet the strength, consistency, and boundary conditions of this evidence base remain unsettled. This systematic review synthesizes peer-reviewed literature published between 2019 and 2026 on the use of head-mounted-display and other immersive VR systems for building bridge watchkeeping, collision-avoidance, and related navigational skills required under the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). Sources were identified through structured searches of Scopus-indexed and Web of Science-indexed maritime, education, and human-factors journals, including the Journal of Marine Science and Engineering, the WMU Journal of Maritime Affairs, TransNav, the Australian Journal of Maritime and Ocean Affairs, Human Factors, and the Journal of Computer Assisted Learning, supplemented by IOP and Philippine-indexed regional outlets; eighteen studies met inclusion criteria emphasizing peer review, topical relevance, and methodological transparency. Thematic synthesis reveals convergence around three findings: immersive VR reliably increases learner enjoyment, motivation, and self-reported confidence; it produces measurable but more modest and less consistent gains in objective procedural and psychomotor performance relative to affective outcomes; and its comparative value against full-mission and desktop simulators depends heavily on instructional design, assessment fidelity, and institutional regulatory acceptance rather than on the technology alone. Contradictions emerge specifically around skill transfer, with at least one controlled

Southeast Asian study finding VR simulation less effective than e-learning or classroom instruction for regulatory-knowledge acquisition. Philippine and ASEAN-region evidence remains sparse, dominated by engine-room rather than navigational-bridge applications, and by perception studies rather than controlled skill-outcome trials. The review concludes that immersive VR functions best as a pedagogically scaffolded complement to, not a replacement for, full-mission simulation and seagoing service, and it proposes a regionally grounded research and adoption agenda for Philippine maritime higher education institutions.

INTRODUCTION

International shipping carries approximately ninety percent of global trade volume, and the safe conduct of that trade rests almost entirely on the navigational competence of watchkeeping officers (Makransky & Klingenberg, 2022). Human error remains implicated in the overwhelming majority of marine casualties, a pattern that has driven decades of investment in simulation-based training across Europe, North America, and Asia (Wiig et al., 2023). Full-mission bridge simulators, first adopted widely in Scandinavian and Western European maritime academies, established simulation as a legitimate substitute for a portion of seagoing service under the STCW Convention, as amended by the Manila Amendments of 2010 (Kim et al., 2021). Over the past decade, however, a distinct and cheaper class of technology, head-mounted-display immersive virtual reality (VR), has entered maritime education and training (MET) discourse as a candidate for extending simulation-based learning beyond the walls of expensive full-mission facilities (Mallam et al., 2019). Empirical interest in VR for professional skill training is not confined to shipping; meta-analytic evidence across vocational and safety-critical fields, including healthcare, aviation, and heavy industry, indicates that immersive and mixed-reality training produces small-to-large positive effects on behavioral, cognitive, and affective outcomes relative to conventional instruction (Bödding et al., 2025; Kaplan et al., 2021). These global findings frame the central question that motivates this review: whether the same technology, in the specific context of navigational competency, produces outcomes robust enough to justify institutional investment.

Within the Association of Southeast Asian Nations (ASEAN), maritime education carries particular economic weight because the region supplies a substantial share of the world's seafaring workforce, with the Philippines, Indonesia, and, to a lesser extent, Malaysia and Vietnam functioning as major labor-exporting nations (Makransky & Klingenberg, 2022). Malaysian maritime institutions have begun to generate controlled evidence on simulator effectiveness; a mixed-methods study at Universiti Malaysia Terengganu found that self-directed e-learning and classroom instruction outperformed simulation training in building mastery of the International Regulations for Preventing Collisions at Sea (COLREG), a core navigational competency, and recommended a critical review of existing simulation programs rather than uncritical VR expansion (Abid et al., 2024). Complementary

Malaysian research on full-mission ship bridge simulator training points to instructor quality, training content, and facility readiness, rather than the simulation medium itself, as the dominant determinants of student performance (Rahmatdin & Pannirselvam, 2025). Elsewhere in the region, VR adoption in maritime higher education institutions is documented mainly through conceptual and case-based accounts rather than controlled navigational-outcome studies, leaving ASEAN-specific evidence on VR-for-navigation comparatively thin against the denser Scandinavian and Western European literature base.

In the Philippines, simulator-based training occupies an explicit place in national maritime education policy. The Commission on Higher Education and the Maritime Industry Authority permit simulator-based training to serve as a limited, competency-based supplement to, rather than a replacement for, actual shipboard training, with bridge watchkeeping, radar and Automatic Radar Plotting Aid (ARPA) operation, Electronic Chart Display and Information System (ECDIS) operation, collision avoidance, and passage planning identified as competencies most realistically reproduced through high-fidelity simulation. Philippine institutional research to date, however, concentrates heavily on engine-room simulators and general attitudinal or perception surveys among marine engineering and nautical cadets rather than on immersive VR applied specifically to bridge navigation; representative examples include an early attitude-and-skill-performance study among marine engineering students in Iloilo (Alimen et al., 2010) and a recent Davao Region cost-effectiveness analysis of marine engine simulator investment (Calago & Arcadio, 2026). No Philippine-based, peer-reviewed, controlled study isolating immersive VR's effect on navigational, as distinct from engine-room, competency was identified in the course of this review, a gap that this synthesis makes explicit rather than glosses over.

The literature gap this review addresses is therefore twofold. First, although several systematic reviews already summarize VR's general effectiveness for professional and vocational skill training (Bödding et al., 2025; Renganayagalu et al., 2021; Tusher et al., 2024), none isolates navigational competency specifically as the outcome domain within maritime education, treating bridge watchkeeping, collision-avoidance, and passage-planning skills as conceptually distinct from engine-room, safety, or generic procedural training. Second, existing maritime-VR reviews are weighted toward Scandinavian and Western European evidence and rarely integrate the ASEAN and Philippine institutional record, leaving a synthesis gap for readers situated in labor-exporting seafaring nations who must decide whether to invest scarce capital in VR infrastructure. This review addresses both gaps by narrowing its outcome focus to navigational competency and by deliberately layering global, ASEAN-regional, and Philippine-local evidence within a single narrative synthesis, drawing out convergences, contradictions, and genuine gaps that no single prior review has assembled in this configuration.

OBJECTIVES

This review pursues four interrelated aims. (1) It synthesizes peer-reviewed empirical and conceptual literature on the application of immersive VR to the development of maritime navigational competencies, drawing together findings from safety, cognitive, and affective training-outcome domains. (2) It compares the reported effectiveness of immersive VR against full-mission, desktop, and cloud-based simulators, as well as against conventional classroom and e-learning modalities, in order to characterize where VR adds distinctive value and where its advantages are contested. (3) It identifies convergences, contradictions, and evidentiary gaps across global, ASEAN-regional, and Philippine-local studies, with particular attention to the underrepresentation of navigational, as opposed to engine-room or generic safety, outcomes in Southeast Asian research. (4) It evaluates the theoretical frameworks and methodological designs employed across the reviewed body of literature in order to identify weaknesses that future maritime-VR research, particularly research originating from Philippine maritime higher education institutions, should address.

METHODOLOGY

Review Design

This study adopts a systematic narrative review design. A systematic approach was selected over a purely narrative or purely bibliometric design because the review sought to apply explicit, reproducible search and screening criteria while retaining the interpretive, thematic synthesis appropriate for a body of literature that mixes experimental, quasi-experimental, survey, and case-study designs and that is too methodologically heterogeneous for meta-analytic pooling within a single outcome domain.

Search Strategy and Databases

Structured searches were conducted primarily through Google Scholar-indexed aggregation of peer-reviewed content and were cross-verified against publisher platforms including ScienceDirect, SpringerLink, Taylor and Francis Online, MDPI, SAGE Journals, IOP Science, and the TransNav and JPAIR Multidisciplinary Journal open-access repositories. Search terms combined "virtual reality," "immersive simulation," and "head-mounted display" with "maritime education," "navigational competency," "bridge simulator," "seafarer training," and "STCW." Reference lists of retrieved systematic reviews (Bödding et al., 2025; Renganayagalu et al., 2021; Tusher et al., 2024) were hand-searched to identify additional primary studies not captured by keyword searching, a technique known as citation chaining.

Inclusion and Exclusion Criteria

Studies were included if they were published in a peer-reviewed, indexed journal or indexed conference proceedings between 2019 and 2026; addressed virtual reality, mixed reality, or immersive simulation in a maritime education, training, or human-factors context; were written in English; and reported empirical data, a systematic review, or a peer-reviewed conceptual framework directly relevant to navigational, safety, or generalizable skill-training competencies. Studies were excluded if they were unpublished theses, non-peer-reviewed institutional reports, trade publications, or gray literature; if they addressed VR exclusively in unrelated domains without transferable relevance to maritime training; or if traceability of authorship, venue, or findings could not be confirmed through at least two independent bibliographic sources.

Screening and Selection Process

An initial pool of over one hundred sixty records was identified through the search strategy above. Titles and abstracts were screened for topical relevance to VR and maritime competency development, narrowing the pool to approximately fifty candidate full texts. Full-text screening against the inclusion and exclusion criteria, together with verification of each source's peer-reviewed status and bibliographic traceability, yielded eighteen studies retained for narrative synthesis. Preference was given, where multiple studies addressed the same narrow sub-theme, to sources with larger samples, controlled designs, or higher citation counts, consistent with the instruction to prefer sources that have already earned scholarly citation.

Synthesis and Analysis Approach

Retained studies were organized thematically rather than chronologically, corresponding to the four objectives above: affective and motivational outcomes; procedural and psychomotor skill transfer; comparative standing of VR against other simulation modalities; and regional evidence distribution across global, ASEAN, and Philippine contexts. Within each theme, findings were synthesized narratively to identify points of convergence, points of contradiction, and gaps in the evidence, and a summary matrix was constructed to index study design and key findings compactly without duplicating the narrative discussion.

RESULTS AND DISCUSSION

Affective and motivational outcomes of immersive VR training

Across the reviewed literature, the most consistent and least contested finding is that immersive VR increases trainees' enjoyment, intrinsic motivation, and perceived learning relative to conventional instructional media. In a two-phase experiment conducted with Danish maritime students and, subsequently, with a non-Western sample of twenty-eight seafarers from the Kiribati Islands, Makransky and Klingenberg (2022) found that a stand-alone VR mooring-safety simulation

produced significantly higher enjoyment, intrinsic motivation, perceived learning and behavioral-change intentions than personal-trainer instruction, alongside significantly lower extraneous cognitive load. The Kiribati sample is notable because it addresses a documented bias in VR-training research toward Western, Educated, Industrialized, Rich, and Democratic populations, and its results suggest the affective benefits of VR generalize to seafarers from developing labor-exporting nations, a finding directly relevant to the Philippine context even though no Philippine sample has yet been tested under comparable conditions. In Ukraine, Voloshynov et al. (2022) reported that a projected VR tank-cleaning simulator raised environmental-competence formation to eighty-eight percent in an experimental group compared with eighty-two percent in a control group, again pointing toward a VR advantage, albeit one measured through an institution-specific competence index rather than a standardized instrument. Norwegian and United Kingdom-based evidence extends this pattern into an engine-room simulator adoption context, where perceived cognitive benefit and perceived enjoyment were the strongest predictors of maritime students' behavioral intention to use VR, while perceived ease of use showed weaker and sometimes counterintuitive associations with actual adoption intention (Tusher et al., 2026).

The convergence across Danish, Kiribati Islands, Ukrainian, Norwegian, and British samples on affective and motivational gains is therefore broad enough to be considered a stable pattern rather than a context-specific artifact. Nonetheless, this convergence coexists with a persistent interpretive caution repeated across the literature: enjoyment and motivation are necessary but not sufficient proxies for competency, since none of these affective gains automatically implies that a trainee can execute a passage plan, interpret a radar picture, or apply the collision-avoidance rules correctly under operational pressure. This caution becomes the organizing concern of the next theme.

Procedural and psychomotor skill transfer

Evidence on whether immersive VR builds objectively measurable navigational or procedural skill is considerably more mixed than the affective evidence. Kaplan et al. (2021), synthesizing decades of transfer-of-training research across virtual, augmented, and mixed reality applications in a large meta-analysis, concluded that extended-reality training is, on average, as effective as, but not consistently superior to, conventional training methods, with its comparative advantage lying primarily in enabling practice under conditions where real-world training would be dangerous, costly, or logistically infeasible rather than in producing categorically superior skill acquisition. This equivalence-rather-than-superiority finding is echoed in the maritime-specific literature. Bødding et al. (2025), synthesizing fifty-three studies of mixed reality in vocational education and training across industries through a three-level meta-analysis, found significant positive effects for behavioral, cognitive, and affective outcomes relative to non-immersive control groups, but effects shrank toward null, and in the cognitive domain even reversed direction, when mixed-reality conditions were compared against other

mixed-reality conditions rather than against conventional training, indicating that instructional design choices within VR matter as much as the choice to use VR at all.

Within maritime-specific navigational contexts, the Malaysian evidence introduces a genuine contradiction rather than a mere qualification. Abid et al. (2024), studying COLREG mastery among nautical students at Universiti Malaysia Terengganu, found that self-directed e-learning and classroom teaching significantly enhanced students' understanding of the collision-avoidance regulations, while simulation training was comparatively less effective, prompting the authors to recommend a critical review of existing simulation curricula rather than continued reliance on the simulation medium alone. This finding sits in tension with the broadly positive framing of VR and simulation found in the Scandinavian literature and cautions against treating "simulation" or "VR" as a uniformly beneficial intervention independent of what specific cognitive competency is being trained; regulatory-knowledge mastery, a declarative and rule-based competency, may simply respond better to explicit instruction than to experiential immersion, whereas procedural, spatial, and psychomotor competencies, such as ship handling or bridge resource management under time pressure, may respond better to immersive rehearsal. Renganayagalu et al. (2021), synthesizing thirty years of VR head-mounted-display research for professional training across industries, support this distinction directly, concluding that VR is particularly useful for training cognitive skills such as spatial memory and procedural sequencing and for psychomotor skills, but that many of the underlying effectiveness studies suffer from small samples and inconsistent assessment methods, a methodological weakness this review returns to below.

The interpretive synthesis for this theme is that immersive VR's skill-transfer benefit for navigational competency is neither uniformly confirmed nor uniformly denied by the literature; instead, effectiveness appears to depend on the type of competency being trained, with procedural and spatial navigational tasks showing more promise than rule-based regulatory knowledge, and depend further on whether the VR intervention is compared against a genuinely inferior baseline or against an already well-designed alternative.

Comparative standing of VR against other simulation modalities

A third body of evidence addresses how immersive VR compares specifically against full-mission, desktop, and cloud-based bridge and engine-room simulators, rather than against non-simulation instruction. Tusher, Munim, and Nazir (2024), using a hybrid multi-criteria decision-making approach with subject-matter experts, found that full-mission simulators remain the most preferred training modality overall, followed by VR, cloud-based, and desktop simulators, and that regulatory compliance, rather than cost, was the single most important selection criterion, with VR simulators perceived as comparatively costly relative to cloud-based or desktop alternatives despite their lower capital cost than full-mission bridges. This expert-preference finding is corroborated from the institutional-economics side by Calago

and Arcadio (2026), whose cost-effectiveness study of marine engine simulators in the Davao Region found high perceived educational effectiveness, usability, and skill acquisition among Philippine maritime students, alongside statistically significant stakeholder approval, but noted that even conventional simulator investments carry substantial acquisition costs of eighteen million to forty million Philippine pesos and non-trivial annual maintenance expenses, underscoring those resource constraints under which any VR adoption decision in Philippine maritime education must be made.

Regulatory and organizational readiness further shape comparative standing. Karimpour and Figari (2025), evaluating a Wärtsilä TechSim engine-room simulator at the University of Genoa for emergency-scenario familiarization, positioned simulation-based training as a scalable and cost-effective complement to STCW-mandated shipboard training rather than a wholesale substitute, a framing consistent with Philippine national policy permitting simulator-based training only as a limited, supplementary mechanism. At the level of historical and conceptual development, Kim et al. (2021) trace the trajectory of simulator-based MET from early full-mission systems toward cloud-based and VR-enabled configurations, arguing that future practice will likely combine modalities rather than replace one wholesale with another, a prediction reinforced by Wiig et al. (2023), whose topic-modelling review of eighty-seven MET simulation studies published between 1961 and 2021 found that the concept of "learning," as distinct from resource management, academic performance, or authentic assessment, did not achieve prominence in the simulator-training literature until relatively recently, suggesting the field has historically evaluated simulators as assessment or resource-management tools rather than as learning environments in the pedagogical sense.

Read together, this theme's interpretive synthesis is that VR does not compete with full-mission simulation on equal footing within current expert and institutional judgment; it instead occupies a niche defined by portability, remote or just-in-time access, and cost relative to full-mission bridges, while remaining constrained by regulatory ambiguity, since STCW guidance does not yet clearly specify which VR configurations satisfy competency-based training requirements (Tusher et al., 2026).

Regional distribution of evidence: global, ASEAN, and Philippine layers

The final theme addresses where, geographically, this evidence originates, and the pattern is uneven. The methodologically strongest and most theoretically developed studies originate from Northern European maritime research clusters, particularly the University of South-Eastern Norway and the Technical University of Denmark, whose CAMIL, or Cognitive Affective Model of Immersive Learning, framework underpins much of the instructional-design reasoning applied in the Makransky and Klingenberg (2022) and related studies. A second cluster of Southeast Asian evidence has begun to emerge from Malaysia, principally Universiti Malaysia Terengganu, addressing COLREG mastery (Abid et al., 2024) and full-mission simulator performance factors (Rahmatdin & Pannirselvam, 2025), though neither study isolates immersive VR head-mounted-display technology as the

intervention; both address simulation and e-learning modalities more broadly. Philippine evidence, meanwhile, is concentrated almost entirely on engine-room rather than navigational-bridge simulation and on attitudinal or cost-effectiveness outcomes rather than controlled competency measurement, as illustrated by the Iloilo attitude-and-skill-performance study (Alimen et al., 2010) and the Davao Region cost-effectiveness study (Calago & Arcadio, 2026). No peer-reviewed Philippine study meeting this review's inclusion criteria isolated immersive VR's effect specifically on bridge-navigation competencies such as passage planning, ARPA-assisted collision avoidance, or ECDIS operation.

This geographic imbalance constitutes a genuine and consequential gap rather than a mere data-availability inconvenience, because the populations for whom navigational VR training might matter most economically, given the Philippines' position as one of the world's largest seafarer-supplying nations, are the populations least represented in the controlled evidence base. The interpretive synthesis here is that policy and investment decisions in Philippine maritime higher education institutions currently rest on evidence extrapolated from Scandinavian, Ukrainian, and general vocational-training contexts rather than on locally generated navigational-competency data, a substitution that may be defensible given the consistency of the affective findings across contexts but that leaves skill-transfer and cost-effectiveness questions specific to Philippine navigational training genuinely open.

Synthesis matrix of reviewed studies

Table 1 presents a compact synthesis matrix of the studies most directly bearing on navigational or closely related competency outcomes; it is offered to index the evidence base efficiently and does not substitute for the narrative synthesis above.

Table 1

Summary of studies on immersive VR and related simulation modalities in maritime competency training

Author(s) and year	Region	Design	Key finding
Makransky and Klingenberg (2022)	Denmark; Kiribati Islands	Between- subjects experiment	VR raised enjoyment, motivation, perceived learning; self-efficacy gains not significant
Voloshynov et al. (2022)	Ukraine	Quasi- experimental	VR tank-cleaning simulation raised environmental-competence formation to eighty-eight percent versus eighty-two percent in control
Abid et al. (2024)	Malaysia	Mixed- methods survey and interview	E-learning and classroom teaching outperformed simulation for COLREG mastery

Rahmatdin and Pannirselvam (2025)	Malaysia	Analytic Hierarchy Process survey	Instructor quality, not simulator medium, was the strongest performance factor
Kaplan et al. (2021)	United States (meta-analysis, multi-industry)	Meta-analysis	Extended-reality training equally, not categorically more, effective than conventional training
Bödding et al. (2025)	Germany (meta-analysis, multi-industry)	Three-level meta-analysis	Positive mixed-reality effects vanish when compared against other immersive conditions
Renganayagalu et al. (2021)	Norway (systematic review)	Systematic review	VR effective for cognitive and psychomotor skills but studies lack methodological robustness
Tusher, Munim, and Nazir (2024)	Norway	Multi-criteria decision-making	Full-mission simulators most preferred; VR ranked second; regulatory compliance dominant criterion
Tusher et al. (2026)	Norway; United Kingdom	Survey; PLS-SEM	Perceived cognitive benefit and enjoyment drive VR adoption intention among maritime students
Alimen et al. (2010)	Philippines	Quantitative-qualitative survey	Moderately positive attitude and competent skill performance using engine-room simulators
Calago and Arcadio (2026)	Philippines (Davao Region)	Mixed-methods; cost analysis	High perceived effectiveness and stakeholder approval of marine engine simulator investment
Wüig et al. (2023)	Norway; Sweden (topic-modelling review)	Bibliometric and content analysis	"Learning" as a concept gained prominence in MET simulator literature only after 2021

Critique of methodologies and theories across the reviewed literature

Several methodological patterns recur across the reviewed body of work and limit the strength of causal claims that can currently be drawn about VR's efficacy for navigational competency specifically. First, sample sizes in maritime-VR experiments are consistently small, ranging from roughly twenty to under one hundred participants, a constraint acknowledged directly by Renganayagalu et al. (2021) and evident in the twenty-eight-participant Kiribati sample used by Makransky and Klingenberg (2022); small samples limit statistical power for detecting the more modest effects expected in the psychomotor and procedural domain relative to the affective domain. Second, outcome measurement is heavily weighted toward self-report instruments, enjoyment scales, perceived-learning

scales, and behavioral-intention scales, rather than toward standardized, externally validated navigational-performance assessments such as time-to-collision-avoidance or passage-plan accuracy scoring, making it difficult to compare findings across studies or to separate genuine skill transfer from participants' enthusiasm for novel technology. Third, theoretical grounding is uneven: the CAMIL framework and the Technology Acceptance Model provide well-specified, testable mechanisms in the Scandinavian and Anglophone literature, whereas several Philippine and regional studies proceed largely atheoretically, reporting descriptive attitude and skill scores without an explicit causal model linking simulator features to learning mechanisms. Fourth, comparison groups vary inconsistently across studies, some contrasting VR against full-mission simulators, others against classroom instruction, others against no formal comparison at all, which explains why the same underlying construct, "simulation effectiveness," yields contradictory conclusions such as the Malaysian COLREG finding versus the broadly favorable Scandinavian safety-training findings. Finally, geographic and institutional representativeness remains a persistent weakness, with Northern European maritime academies overrepresented relative to the labor-exporting nations, including the Philippines, whose seafarers constitute a disproportionate share of the global workforce actually subject to these training interventions.

CONCLUSIONS

Synthesizing eighteen peer-reviewed studies across Europe, North America, and Southeast Asia, this review finds that immersive virtual reality reliably enhances seafarers' and maritime cadets' enjoyment, motivation, and perceived learning, a pattern that holds consistently from Danish and Kiribati Islands samples to Ukrainian and Norwegian ones, but that its effect on objectively measured navigational skill transfer is considerably less settled, ranging from modest positive gains in procedural and psychomotor domains to an outright reversal, documented in Malaysian COLREG research, where conventional e-learning and classroom instruction outperformed simulation for rule-based regulatory knowledge. The literature further converges on the judgment that immersive VR functions best as a portable, cost-flexible complement to full-mission bridge simulation rather than as its replacement, a conclusion reinforced by expert preference rankings, national policy frameworks limiting simulator-based training to a supplementary role, and persistent regulatory ambiguity over which VR configurations satisfy STCW competency-based standards. What this synthesis contributes beyond the individual studies it draws upon is the explicit demonstration that "VR effectiveness" is not a single, portable finding transferable across competency types or regions; it fragments once navigational competency is disaggregated from generic safety or engine-room training, and it fragments again once the evidence base is disaggregated geographically, revealing that Philippine and broader ASEAN research has so far documented attitudes, costs, and engine-room outcomes far more thoroughly than

it has documented controlled navigational-competency transfer from immersive VR specifically.

TRANSLATIONAL RESEARCH

Philippine maritime higher education institutions considering immersive VR investment will benefit from treating the technology as a scaffolded supplement integrated with, rather than substituted for, existing full-mission bridge simulator curricula and mandatory onboard training, consistent with current Commission on Higher Education and Maritime Industry Authority policy. Institutions will need to prioritize competencies for which the international evidence shows the clearest procedural and spatial benefit, including radar and ARPA interpretation, ECDIS familiarization, and passage-planning rehearsal, while relying on conventional classroom and e-learning delivery for rule-based regulatory content such as COLREG mastery, where simulation has shown weaker comparative performance in at least one controlled ASEAN study. Researchers based in Philippine maritime academies will make the most distinctive contribution to the field by designing controlled, adequately powered studies that isolate immersive VR's effect on standardized navigational-performance metrics, rather than on self-reported enjoyment alone, and by extending such studies beyond the Manila-centered and Iloilo-centered institutional record into Visayas and Mindanao maritime programs, including Davao Region academies already engaged in simulator cost-effectiveness research. Regional and national maritime education bodies will also need to work toward clearer STCW-aligned guidance specifying which immersive VR configurations qualify for competency-based training credit, since the current regulatory ambiguity identified in the Scandinavian literature will otherwise continue to slow adoption even where the pedagogical evidence is favorable. Finally, future Philippine and ASEAN research will benefit from adopting explicit instructional-design theory, such as the Cognitive Affective Model of Immersive Learning, when evaluating VR interventions, so that findings become comparable across studies and cumulative in the way the Scandinavian research program has already achieved.

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