

Effectiveness of Bridge Resource Management-Based Watchkeeping Training in Improving Cadet Readiness on Board: A Mixed-Method Study at Banten Maritime Polytechnic

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ABSTRACT

Bridge watchkeeping is critical to vessel safety and operational efficiency, requiring officers of the watch to maintain a high level of readiness. Bridge Resource Management (BRM) provides an important framework for effective watchkeeping by emphasizing communication, teamwork, decision-making, situational awareness, and workload management. However, previous evidence regarding the effectiveness of BRM training remains inconsistent. This study examined the effect of BRM-based watchkeeping training on cadet readiness during onboard sea training and developed strategies for improving its implementation. A convergent parallel mixed-method design was applied, integrating quantitative and qualitative approaches. Quantitative data were collected from 67 Nautical Science cadets using a 20-item five-point Likert questionnaire, while qualitative data were obtained through participatory observations in a bridge simulator and in-depth interviews. The instrument demonstrated strong validity and reliability, with Cronbach's alpha values of 0.866 for the independent variable and 0.951 for the dependent variable. Regression analysis revealed a significant relationship between BRM-based training and cadet readiness, with an R^2 of 0.541, indicating that training explained 54.1% of readiness variance. The regression coefficient was 0.949. Qualitative findings showed weaker performance in the projection level of situational awareness compared with perception and comprehension. Therefore, training improvement should prioritize more complex and realistic scenarios rather than simply extending training duration

INTRODUCTION

In the conduct of shipping, the performance of the bridge watch is a responsibility determining the safety and operational continuity of the vessel. The officer of the watch is charged with ensuring that the ship proceeds safely, maintaining vigilance towards the surrounding environment, taking sound decisions in critical situations, and sustaining effective communication and coordination among the crew. The complexity and the demands of the role require a high order of readiness in respect of knowledge, skill and professional attitude alike. Watchkeeping training accordingly constitutes a core element of maritime vocational education, particularly for cadets about to undertake sea practice aboard ship.

The urgency of strengthening the human dimension of watchkeeping finds strong empirical support in the maritime safety literature. Analysis of ship collision reports using the Human Factors Analysis and Classification System indicates that the majority of accidents originate in decision error, with preconditions in the form of lost situational awareness, attentional deficit, and weak inter-ship communication and Bridge Resource Management (Chauvin et al., 2013). More recent data-driven work reinforces the pattern, identifying decision making, cognitive capacity, situational awareness and communication as the key seafarer competencies for accident prevention (Shi et al., 2024). Veltsin et al. (2025) establish that decision-making skill functions as the mediator transmitting the synergistic effects of training, leadership and communication upon the strengthening of safety culture.

International standards under STCW 1978 as amended at Manila in 2010 require that watchkeeping training encompass technical navigational capability, command of electronic navigational aids, understanding of the regulations governing navigation, and mental preparedness for decision making. Since that amendment, Bridge Resource Management has been a mandatory component of officer training programmes worldwide. It constitutes the maritime adaptation of Crew Resource Management as developed in the aviation industry, and is designed to optimise the use of all bridge resources, human and technical alike, in order to secure the safety of navigation under all conditions (Praetorius et al., 2020).

Evidence of the effectiveness of Bridge Resource Management training nevertheless remains mixed. O'Connor (2011) found that such training among United States Navy surface warfare officers exerted no significant influence upon attitudes to or knowledge of human factors, and concluded that the principal weakness lay in the construction of course material not grounded in needs analysis. Rottger et al. (2016) obtained comparable findings for classroom-based training among junior naval officers, participants demonstrating better knowledge but no significant difference in attitude, in the demonstration of non-technical skills, or in the success of live exercises. The simulator-based experimental study of Rottger and Krey (2021) found more positive attitudes towards open communication and coordination together with a lower incidence of collision in the trained group, albeit with relatively small effect sizes.

This inconsistency underlines the importance of contextual evaluation of Bridge Resource Management implementation at each providing institution. Praetorius et al. (2020), reviewing publications from 2000 to 2018, record that research focusing specifically upon non-technical skill training and its bearing upon operational safety remains limited. Within Indonesian maritime vocational education, evaluative study of the effectiveness of such training in improving cadet readiness, particularly across the aspects of knowledge, technical skill, mental and physical readiness, and professional attitude, is scarcer still.

This gap is sharpened by the divergent evidence noted above: whereas O'Connor (2011) found inconsistent transfer of Bridge Resource Management training into on-the-job performance and Rottger and Krey (2021) reported gains confined chiefly to classroom-based delivery, no study identified in this review has evaluated such training at an Indonesian maritime vocational institution using a design that couples a statistically estimated training effect with direct behavioural observation of cadets performing the watch. The present study is positioned to close that specific gap.

The present study accordingly set out to analyse the magnitude of the effect of Bridge Resource Management based watchkeeping training upon cadet readiness on board, and to set out strategies for developing that training for cadets of the Nautical Science study programme at Banten Maritime Polytechnic. The novelty of the study lies in its use of a mixed-method design measuring effect magnitude quantitatively while explaining its mechanism through participatory observation of simulator exercises, so that the evaluation does not terminate in the reporting of participant satisfaction as conventional evaluations of such training frequently do. This departs from the designs of O'Connor (2011) and Rottger and Krey (2021), which relied respectively on post-training performance records and questionnaire-based satisfaction measures without triangulating the behavioural dimension of readiness; by contrast, the present design links a statistically estimated effect size to observed cadet conduct at the bridge simulator across all four readiness dimensions, offering an account of how, and not only whether, the training operates.

LITERATURE REVIEW

Watchkeeping and the STCW Standard

The bridge watch is a core function of vessel operation determining the safety of navigation, the accuracy of position keeping, and the prevention of accidents. Its conduct proceeds ideally in accordance with STCW 1978 as amended, particularly those chapters governing watchkeeping duties and rest-hour criteria intended to prevent fatigue among the crew. Watchkeeping consists not merely in occupying the bridge but in the capacity to sustain continuous vigilance, to take rapid decisions, and to employ the whole of the available navigational information, visual and electronic alike, appropriately.

Fatigue constitutes one of the most persistent threats to the quality of the watch. Rajapakse and Emad (2023) argue that fatigue remains an unresolved problem continuing to contribute to accidents at sea notwithstanding the long-standing regulation of rest hours. This indicates that the strengthening of

procedural provisions alone is inadequate unless accompanied by the strengthening of individual and team capacity to manage workload, which is itself one of the principal pillars of Bridge Resource Management.

Bridge Resource Management

Bridge Resource Management is a management approach on the ship's bridge directed at optimising the use of all available resources, human and technical alike, in order to secure the safety of navigation. It was introduced into the shipping industry in response to the high incidence of marine casualties attributable to human error. As a derivative of Crew Resource Management in aviation, it rests upon five principal pillars, namely effective communication, leadership and teamwork, situational awareness, decision making, and workload management.

Communication is the backbone of team operation on the bridge. Communication that is clear, concise and timely ensures that all members of the team hold a common understanding of the situation, and standards such as closed-loop communication are accordingly emphasised. Sound leadership encompasses the issuing of clear instructions, the distribution of tasks according to crew competence, and the constructive management of conflict. Proportionate workload management is in turn important to the maintenance of crew performance and concentration, since excessive load may produce fatigue and lapses of attention bearing adversely upon safety.

Campanico Cavaleiro et al. (2020) argue that command of the non-technical skills inherent in Bridge Resource Management is determinative of the success of maritime operations, particularly in naval contexts demanding high safety standards. Nizar et al. (2022) extend that scope to the engine control room through the development of an approach to the measurement of situational awareness as part of non-technical skill assessment within Engine Resource Management, demonstrating that the framework is transferable across shipboard functions.

Situational Awareness as the Core of the Approach

Situational awareness is the central construct within Bridge Resource Management. Endsley (1995a) formulated a theoretical model of situational awareness in dynamic systems comprising three levels, namely perception of the elements in the environment, comprehension of the meaning of the situation, and projection of its development in the near term. The model places attention and working memory as limiting factors and mental models and goal-directed behaviour as the mechanisms by which those limits are overcome. In its companion paper, Endsley (1995b) reviews the empirical measurement of situational awareness together with the merits and limitations of each approach.

The three-level model has become the dominant reference across high-risk domains. Wickens (2008) reviews the influence of Endsley's two papers upon human factors theory and practice and records their application to training, error analysis, system design, selection, teamwork and automation. Endsley (2015) subsequently responded to criticisms of the model and showed most of them to proceed from misunderstanding of the construct intended. In the bridge context,

failure to maintain situational awareness has been shown to be the proximate cause of numerous major casualties, so that the strengthening of situational awareness constitutes the principal objective of the training.

Effectiveness of Simulator-Based Training

Simulators constitute key infrastructure in maritime education for ensuring that learning outcomes align with the minimum competencies specified under STCW (Kandemir et al., 2018). Kim et al. (2021) record that the COVID-19 pandemic accelerated the adoption of digital technology in Maritime Education and Training, including virtual reality and cloud-based simulation. The systematic review of Dewan et al. (2023) across 27 articles maps the use of immersive and non-immersive simulators and concludes that an evaluation model framed from the learner's perspective is required.

Wiig et al. (2023), employing topic modelling, trace the conceptual development of simulator-based training and assessment in maritime education, while Sellberg et al. (2022) show how professional navigational competence is constructed situationally through post-simulation evaluation. Karahalil et al. (2025) add that variation in the interpretation of STCW standards across countries and institutions produces heterogeneous teaching practice, rendering contextual evaluation at each institution important. In a cognate high-risk domain, Gross et al. (2019), reviewing Crew Resource Management training in healthcare systematically, record that the diversity of intervention design and training conditions bears materially upon evaluation outcomes, a lesson pertinent to the design of maritime training.

Cadet Readiness on Board

Cadet readiness to discharge duties aboard ship reflects the capacity to integrate knowledge, skill, mental disposition and professional attitude in confronting authentic situations in the maritime working environment. Four principal indicators describe that readiness. The first is knowledge, the foundation of every form of readiness, encompassing understanding of navigational principle, international regulation, bridge procedure, and the systems and equipment employed aboard ship. The second is technical skill, which requires that the cadet be able to operate navigational aids, read charts, fix the ship's position, and discharge watchkeeping duties to standard.

The third is mental and physical readiness, which refers to the capacity to sustain concentration, emotional resilience and physical stability throughout extended and demanding watches. The fourth is professional attitude, encompassing discipline, a sense of responsibility, work ethic, compliance with orders, and the capacity to interact effectively with the remainder of the crew. Kuzu (2026) locates self-awareness as the most influential causal criterion within the network of seafarer non-technical skills, while from the employment perspective Succi and Canovi (2020) demonstrate employers' increasing emphasis upon soft skills as a determinant of graduate work readiness.

Conceptual Framework and Hypotheses

On the basis of the foregoing, the study positions Bridge Resource Management based watchkeeping training as the independent variable and cadet readiness on board as the dependent variable, with the mechanism traced through a parallel qualitative strand. The conceptual framework is presented in Figure 1. The hypotheses advanced are H0, that such training exerts no positive effect upon cadet readiness on board, and H1, that it exerts a positive effect upon cadet readiness on board.

The contribution of this study to the literature reviewed above is accordingly twofold. First, it extends single-method evaluations of Bridge Resource Management training (e.g., O'Connor, 2011; Rottger & Krey, 2021) by triangulating a quantitative effect estimate with qualitative behavioural evidence drawn from simulator-based observation. Second, it situates that evaluation within an Indonesian maritime vocational context in which, as Praetorius et al. (2020) observe, research on non-technical skills training remains comparatively scarce, thereby providing a contextually grounded basis for developing such training at other providing institutions.

METHODOLOGY

Research Design

The study employed a mixed-method design following a Convergent Parallel scheme, in which quantitative and qualitative approaches proceed concurrently, are analysed separately, and are subsequently compared and combined. The quantitative approach centred upon the analysis of numerical data by statistical means, while the qualitative approach proceeded argumentatively from observational and interview material. The conceptual framework and research design are presented in Figure 1.

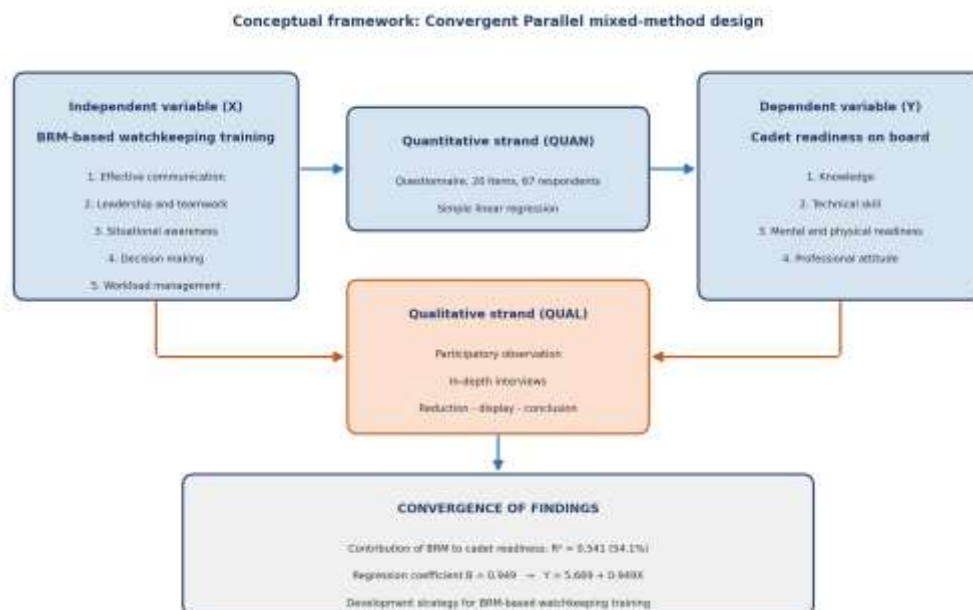


Figure 1. Conceptual Framework of the Convergent Parallel Mixed-Method Design Linking BRM-Based Watchkeeping Training To Cadet Readiness On Board.

Variables and Operational Definitions

The independent variable is Bridge Resource Management based watchkeeping training, defined as practice-based learning in the discharge of watchkeeping duties integrating the principles of Bridge Resource Management. It is measured through five indicators, namely effective communication, leadership and teamwork, situational awareness, decision making, and workload management. The dependent variable is readiness on board, defined as the cadet's physical, mental, cognitive, practical and attitudinal preparedness to discharge duties and responsibilities effectively during sea practice in accordance with maritime standards of safety, professionalism and work ethic. It is measured through four indicators, namely knowledge, technical skill, mental and physical readiness, and professional attitude.

Population, Sample and Sampling Technique

The population comprised cadets of the Nautical Science study programme at Banten Maritime Polytechnic, 119 from the 2022 intake and 85 from the 2023 intake, totalling 204. Sample size was determined using the Slovin formula at a significance level of 10%, yielding a minimum requirement of 67 respondents. Respondents were selected by incidental sampling among cadets undertaking or having completed sea practice, on the consideration that this group had direct experience of applying the training in an authentic operational context.

Inclusion and Exclusion Criteria

Cadets were eligible for inclusion where they were formally enrolled in the Nautical Science study programme at Banten Maritime Polytechnic and had undertaken or completed a period of sea practice, this experience being required for a meaningful judgement of readiness on board. Cadets who had not yet commenced sea practice were excluded from the sampling frame, as were questionnaire returns that were incomplete or displayed a uniform response pattern indicative of inattentive responding.

Instruments and Data Collection

The principal instrument was a closed questionnaire of 20 statement items measured on a five-point Likert scale, comprising ten items for the independent variable and ten for the dependent variable. Qualitative data were collected through participatory observation of training conducted at the Bridge Simulator of Banten Maritime Polytechnic together with in-depth interviews with at least five cadets of the Nautical Science study programme. In the course of observation the researchers recorded detailed notes upon the attitude, conduct and skill displayed by cadets during the exercises.

Instrument Validity and Reliability

Validity was tested using the Pearson Product Moment correlation, an item being declared valid where the calculated r exceeded the tabulated r at a significance level of 0.05 on a two-tailed test. Reliability was tested using Cronbach's alpha in order to confirm the capacity of the instrument to yield

consistent results. An item was retained where its calculated r exceeded the tabulated r of 0.3388 at $df = n - 2$ (65) and a significance level of 0.05, while reliability was required to exceed the conventional threshold of Cronbach's $\alpha = 0.60$; the instrument returned α values of 0.866 for the independent variable and 0.951 for the dependent variable, both categorised as highly reliable (Table 1).

Data Analysis

Quantitative analysis employed simple linear regression in order to examine the causal relationship between the independent and dependent variables. Prior to hypothesis testing, the assumptions were tested through a test of linearity, a test of normality using the Kolmogorov-Smirnov statistic, and a test of heteroscedasticity using the Glejser test. Hypothesis testing proceeded through the F test, assessing the significance of the model as a whole, and the t test, assessing the partial effect of the independent variable, significance being declared where the significance value fell below 0.05. The coefficient of determination was used to measure the contribution of the independent variable to the explanation of variance in the dependent variable. Qualitative analysis proceeded through three principal components, namely data reduction, data display, and conclusion drawing with verification.

Ethical Considerations

Participation was voluntary, and cadets were informed of the purpose and procedure of the study before providing their consent; individual responses were treated confidentially and used for research purposes only. [Author/institution to insert the reference number of the ethical clearance or institutional review, if applicable, before submission.]

RESEARCH RESULT

Respondent Characteristics

Respondents comprised cadets of the 2022 intake who had completed sea practice, at 52.94%, and cadets of the 2023 intake still undertaking it, at 47.06%. By sex, the majority were male, at 67.65%, the remaining 32.35% female. This composition ensures that assessments of readiness on board derive from respondents possessing direct experience of the shipboard operational environment.

Instrument Testing

The credibility of the instrument was established through two stages of analysis, namely validity and reliability testing. The results are presented in Table 1.

Table 1. Results of Instrument Validity and Reliability Testing.

Item	Calculated r	Result	Item	Calculated r	Result
X1	0.820	Valid	Y1	0.785	Valid
X2	0.686	Valid	Y2	0.795	Valid

Item	Calculated r	Result	Item	Calculated r	Result
X3	0.620	Valid	Y3	0.706	Valid
X4	0.656	Valid	Y4	0.802	Valid
X5	0.585	Valid	Y5	0.731	Valid
X6	0.577	Valid	Y6	0.846	Valid
X7	0.670	Valid	Y7	0.871	Valid
X8	0.647	Valid	Y8	0.817	Valid
X9	0.664	Valid	Y9	0.869	Valid
X10	0.790	Valid	Y10	0.816	Valid
Cronbach's alpha X	0.866	Reliable	Cronbach's alpha Y	0.951	Reliable

Testing across items X1 to X10 and Y1 to Y10 returned calculated r values above the tabulated value of 0.3388 throughout. Items X1 to X10 are accordingly valid measures of Bridge Resource Management based watchkeeping training, and items Y1 to Y10 valid measures of readiness on board. Reliability testing returned a Cronbach's alpha of 0.866 for the independent and 0.951 for the dependent variable, indicating very good internal consistency. The satisfaction of validity and reliability supplies a firm basis for regarding the instrument as capable of representing respondents' actual condition.

Assumption Testing

Prior to hypothesis testing, the classical assumptions were tested in order to confirm that the interpretation of the regression model contains no violation liable to affect the accuracy of generalisation. The results are presented in Table 2.

Table 2. Results of Assumption Testing for Simple Linear Regression.

Test	Statistic	Sig.	Interpretation
Test of linearity	F = 52.080	< 0.001	Significant linear relationship
Kolmogorov-Smirnov	0.135	0.117	Residuals normally distributed
Glejser test	t = -1.220	0.231	No heteroscedasticity present

The test of linearity returned a significance below 0.001, indicating a significant linear relationship between the training and cadet readiness on board, so that the linear regression model is appropriate. The Kolmogorov-Smirnov test of normality returned a significance of 0.117, exceeding 0.05, so that the residuals are normally distributed and the generalisation of model results may be regarded

as validly describing the population. The Glejser test of heteroscedasticity returned a significance of 0.231, exceeding 0.05, so that the residual variance may be regarded as constant.

Hypothesis Testing

All assumptions being satisfied, hypothesis testing proceeded by simple linear regression. The results of the overall test, the partial test, and the coefficient of determination are presented in Table 3.

Table 3. Results of the Simple Linear Regression Model.

Test	Coefficient / statistic	Sig.	Interpretation
F test (overall)	F = 37.754; df = 1; residual = 65	< 0.001	Model significant
Constant	B = 5.669; t = 0.874	0.389	-
BRM-based watchkeeping (X)	B = 0.949; t = 6.144	< 0.001	Significant positive effect
Correlation coefficient (R)	0.736	-	Strong relationship
Coefficient of determination (R squared)	0.541	-	Accounts for 54.1 % of variance
Standard error of the estimate	4.080	-	-

The F test returned an F value of 37.754 at a significance below 0.001, so that the regression model is significant. The t test upon the independent variable returned a t value of 6.144 at a significance below 0.001 with a positive regression coefficient of 0.949, so that the research hypothesis is answered: the quality of Bridge Resource Management based watchkeeping training exerts a positive effect upon the level of cadet readiness on board. The regression equation obtained is $Y = 5.669 + 0.949X$, signifying that each one-unit increase in training quality raises cadet readiness by 0.949 units.

The coefficient of determination of 0.541 indicates that 54.1% of the variance in cadet readiness on board is explained by the training, the remaining 45.9% being explained by factors outside the model, among them initial competence and skill, individual discipline, working environment, and the psychological condition of the cadet.

Observation and Interview Findings

The training was conducted at the Bridge Simulator of Banten Maritime Polytechnic by lecturers of the Nautical Science study programme. Cadets were prepared in voyage planning, chart interpretation and inter-team communication, with the object of developing teamwork, situational awareness,

decision making, communication, workload management and monitoring. They obtained simulated experience of shipboard duties encompassing the distribution of tasks among watchkeeping officers and the team, coordination and communication including the handover of the watch, decision making, and risk management. A summary of the observation and interview findings is presented in Table 4.

Table 4. Observation and Interview Findings on BRM Training and Readiness on Board.

Readiness dimension	Observation and interview findings	Implication for training development
Knowledge	Cadets able to read charts, fix the ship's position, interpret symbols, and understand and follow watchkeeping procedure	Training improves navigational knowledge, understanding of role during the watch, and regularity of watchkeeping to procedure
Technical skill	Cadets active in operating navigational equipment and correcting course, though some still require guidance in complex scenarios	Frequency of practice improves technical skill and operational capability significantly
Mental and physical readiness	Some cadets showed declining focus and appeared hesitant in taking rapid decisions under emergency conditions	Training in sustained attention, habituation to rapid decision making, and scenarios of greater complexity are required
Professional attitude	Cadets employed formal communication and displayed sound conduct in teamwork and logbook keeping	Professionalism is beginning to form but requires mentoring if procedural discipline and communication ethics are to become consistent

During training, cadets received assignments in groups, held discussions, discharged the visual watch, monitored bridge navigational equipment, computed the ship's position and calculated distance run. They were also afforded scope to construct decisions by reference to the Regulations for Preventing Collisions at Sea. On the basis of these observations, increased intensity and more effective use of training time not only augment cadets' technical knowledge but strengthen collaborative working patterns in the conduct of the watch.

DISCUSSION

The coefficient of determination of 0.541 indicates that Bridge Resource Management based watchkeeping training accounts for more than half the

variance in cadet readiness on board. This magnitude is substantial for a single training intervention, the more so when set against earlier studies, which tend to report small effects. O'Connor (2011) found no significant effect upon officers' attitudes or knowledge, while Rottger et al. (2016) found a difference on the dimension of knowledge alone, with none in attitude or in the demonstration of non-technical skills. Rottger and Krey (2021) obtained positive effects upon attitudes towards open communication and a reduction in the incidence of collision, but with small effect sizes.

The difference in effect magnitude may be explained through the characteristics of training design. O'Connor (2011) identified the principal weakness of the programme evaluated as the construction of material not grounded in analysis of the needs of the target community, while Rottger et al. (2016) concluded that a training focus upon knowledge, skills and attitudes of a general character, without specific application to the context of live exercise, accounted for the low effectiveness observed. Rottger and Krey (2021) surmised that the limited scale of an intervention comprising a single cycle of instruction, practice and feedback constrained the effect obtained. The training evaluated here is by contrast integrated with watchkeeping practice in the simulator and was undertaken by respondents who had completed or were undertaking sea practice, so that application within an authentic operational context is better assured.

The qualitative findings reinforce this interpretation while disclosing an aspect the figures do not capture. On the dimensions of knowledge and technical skill, cadets displayed adequate command in reading charts, fixing the ship's position and operating navigational equipment. In complex scenarios, however, such as navigation in restricted waters, dense traffic and adverse weather, cadets appeared hesitant in decision making. This pattern is consistent with the three-level model of Endsley (1995a), in which capability at the levels of perception and comprehension is more readily formed than capability at the level of projection, which demands anticipation of how the situation will develop.

The observed decline in cadet focus under emergency conditions likewise accords with Endsley's (1995a) emphasis upon attention and working memory as the principal limiting factors in the formation of situational awareness, particularly under high workload and time pressure. Wickens (2008) records the wide application of the construct to training design across high-risk domains, while Endsley (2015) affirms its relevance in explaining team performance. The implication for the present case is that extending training duration alone is inadequate unless accompanied by a deliberate increase in scenario complexity directed specifically at the exercise of projection. This, rather than the coefficient itself, is the practical yield of the mixed-method design.

From the standpoint of safety at sea, the strengthening of decision-making capability observed here carries direct relevance. Chauvin et al. (2013) found the majority of ship collisions to originate in decision error with preconditions of weak Bridge Resource Management and lost situational awareness, while Shi et al. (2024) identify decision making and situational awareness as key competencies for accident prevention. Veltsin et al. (2025) locate decision-making

skill as the mediator transmitting the effects of training, leadership and communication upon safety culture. The improvement in cadet readiness identified here may accordingly be regarded as a preventive investment against the risk of casualty.

The finding on the dimension of professional attitude, where professionalism is beginning to form but requires mentoring if it is to become consistent, accords with the emphasis of Campanico Cavaleiro et al. (2020) that non-technical skills require continuing programmes of training rather than momentary intervention. Gross et al. (2019), reviewing Crew Resource Management training in healthcare, record that the diversity of intervention design and training conditions bears materially upon evaluation outcomes, indicating the importance of standardised training design accompanied by contextual adjustment. Sellberg et al. (2022) show that professional navigational competence is in fact constructed situationally through post-simulation evaluation, so that the debriefing session requires positioning as a core component of training rather than as an adjunct.

Several limitations qualify the interpretation of these results. First, the design is cross-sectional and without a control group, so that the relationship identified evidences strong association but does not fully establish causation. Second, incidental sampling carries a risk of selection bias, in that respondents willing to participate may differ in character from the population. Third, readiness was measured through respondents' self-perception rather than through objective performance assessment by instructors or ship's officers, and is therefore susceptible to social desirability bias. Wiig et al. (2023) emphasise the importance of developing more objective simulator-based assessment methods, while Nizar et al. (2022) offer an example of an approach to the measurement of situational awareness capable of adaptation in further research.

CONCLUSIONS AND RECOMMENDATIONS

Bridge Resource Management based watchkeeping training exerts a positive and significant effect upon cadet readiness on board, contributing 54.1% of the variance in readiness. The regression coefficient of 0.949 indicates that each one-unit increase in training quality raises cadet readiness by 0.949 units across the aspects of knowledge, technical skill, mental and physical readiness, and professional attitude alike. The approach is accordingly established as a key factor in strengthening technical and mental capability, team coordination and decision making in the conduct of the watch.

Four steps are recommended for the development of such training. First, the development of structured modules integrated with case studies, current issues and emergency simulation in order to enrich cadets' knowledge and technical skill. Second, intensive mentoring in the conduct of the watch in accordance with standard operating procedure, accompanied by the practice of technical navigational skill in scenarios of greater complexity. Third, the integration of bridge team crisis management and rapid decision making so that cadets become accustomed to responding to risk swiftly, accurately and in a coordinated manner. Fourth, the reinforcement of safety culture through safety

briefing before and debriefing after training, accompanied by periodic evaluation of logbook keeping, communication and the discharge of responsibility.

ADVANCED RESEARCH

Four directions are recommended for further work. First, the application of a quasi-experimental design with a control group and pre- and post-intervention measurement in order to strengthen causal inference concerning training effectiveness. Second, the addition of further variables liable to bear upon cadet readiness, such as individual discipline, psychological condition, initial competence, and fatigue as highlighted by Rajapakse and Emad (2023). Third, the use of objective performance measures based upon structured observation or instructor assessment in order to reduce reliance upon self-perception, drawing upon the approach to non-technical skill assessment developed by Nizar et al. (2022). Fourth, longitudinal study tracing the transfer of training outcomes to actual performance during sea practice and the early working life of graduates.

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