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The Effect of Training and Safety Knowledge on Crew Competence and its Implications for Occupational Safety Onboard at PT. Gelora Persada Makmur

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Abstract: This study aims to analyze the effect of safety training and safety knowledge on crew competence and its implications for occupational safety on board ships at PT. Gelora Persada Makmur. This research employs a quantitative research design using a survey method with a cross-sectional approach. The population of this study consists of all ship crew members of PT. Gelora Persada Makmur, totaling 100 respondents. A saturated sampling technique was applied, in which the entire population was used as the research sample. Data were collected through a closed-ended questionnaire using a five-point Likert scale distributed online. The collected data were analyzed using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method with the assistance of SmartPLS software. The results of this study are expected to indicate that safety training and safety knowledge have a positive effect on crew competence, both directly and indirectly, and that crew competence has a positive effect on occupational safety on board. These findings are expected to serve as a basis for improving operational safety management within the company.

Keyword: Safety Training, Safety Knowledge, Crew Competence, Occupational Safety.

INTRODUCTION

Occupational safety onboard is a critical factor in ensuring the successful operation of vessels and protecting crew members from potential hazards encountered during mari-time duties. PT. Gelora Persada Makmur, as a company engaged in ship management, bears a substantial responsibility to ensure that all crew members possess adequate competence and sufficient safety knowledge. In this context, safety training and safety knowledge repre-sent two fundamental elements in maintaining workplace safety and minimizing the risk of maritime

accidents. These components are essential not only for compliance with safety standards but also for fostering a proactive safety culture within maritime operations.

Despite the relatively comprehensive safety training programs implemented by PT. Gelora Persada Makmur, several limitations remain evident. One notable issue is the limited number of participants involved in each training session, which may reduce the overall effectiveness of the program. For instance, fire-handling training conducted on MV. Lascombes involved only 25 crew members, potentially leaving other personnel without ad-equate preparation for emergency situations. Such limitations may lead to uneven distribu-tion of knowledge and skills among crew members, thereby increasing vulnerability during critical incidents. Furthermore, the lack of continuous and inclusive training programs pre-vents the consistent reinforcement of safety competencies across all crew members, ulti-mately affecting their readiness to respond to operational risks.

Another challenge lies in the limited duration of training programs and the absence of regular refresher courses. For example, emergency evacuation training conducted over a short period without periodic updates may not sufficiently address evolving operational conditions or technological advancements onboard. Without continuous learning and skill reinforcement, crew members may gradually lose previously acquired knowledge, which can increase the likelihood and severity of workplace accidents. Therefore, ongoing and struc-tured training programs are essential to ensure that crew members remain competent and responsive to dynamic maritime risks.

In addition, the company faces significant challenges related to insufficient pre-deployment training and familiarization processes. Inadequate training or lack of familiarity with onboard safety procedures can leave crew members unprepared for high-risk working conditions, thereby elevating the probability of accidents. Effective training programs should comprehensively cover basic safety procedures, fire response, accident handling, and the proper use of safety equipment. Ensuring that all crew members undergo systematic fa-miliarization before deployment is crucial in enhancing operational safety and reducing risk exposure.

Preliminary survey results further indicate that safety training at PT. Gelora Persada Makmur has not been perceived as fully optimal by crew members. Several respondents expressed dissatisfaction with the completeness of training materials and the frequency of training sessions. Training methods were also considered insufficient in simulating real-life onboard conditions, while instructor quality was perceived as inconsistent. Moreover, post-training evaluation mechanisms were not systematically implemented, potentially limiting the effectiveness of knowledge transfer. These conditions may reduce crew preparedness in handling emergency situations and highlight the need for a more structured and consistent training system.

Safety knowledge constitutes another critical factor influencing crew competence and safety performance. It reflects the extent to which crew members understand safety pro-cedures, risks, and regulatory requirements. However, preliminary findings reveal signifi-cant gaps in safety knowledge among crew members at PT. Gelora Persada Makmur. Many crew members lack formal safety certifications due to limited access to training facilities and insufficient opportunities for continuous learning. Although some personnel possess certifications such as fire-handling and first aid obtained in previous years, gaps remain in fundamental areas such as emergency evacuation and navigation safety. This deficiency in knowledge may negatively impact the ability of crew members to respond effectively to emergencies, thereby increasing the severity of potential accidents.

The variability in safety knowledge among crew members further indicates a discrepancy between training exposure and actual understanding in practice. While knowledge related to the use of safety equipment appears relatively adequate, comprehension of safety regulations and hazard awareness remains uneven. This suggests that accident prevention has not yet been fully internalized as a habitual work practice. Consequently, enhancing safety

knowledge through continuous and systematic training initiatives becomes an urgent priority to reduce workplace risks and improve safety outcomes.

A review of prior studies indicates that most research has examined safety training, safety knowledge, and crew competence in a fragmented manner. Previous studies have fo-cused on diverse aspects such as energy-efficient operations and SEEMP implementation (Dewan et al., 2024), data-driven and Bayesian approaches to maritime safety (Shi et al., 2024), stakeholder perceptions of onboard training (Phanphichit & Bartusevičienė, 2024), and both technical and non-technical competencies (Kuzu, 2025; Gumelar et al., 2021). Oth-er studies have demonstrated that safety training positively influences knowledge, readiness, leadership, and performance (Kamis et al., 2020; Suprapti, 2024; Nurahaju & Utami, 2020; Prayogo et al., 2025), while additional research highlights the role of regulatory frameworks, STCW compliance, safety climate, and supervision in shaping safety behavior (Sulistiana & Rachman, 2023; Dipta et al., 2023; Mišković et al., 2022; Chan et al., 2019; Kurniawan et al., 2023).

However, there remains a significant research gap, as no study has comprehensively examined the causal relationships between safety training and safety knowledge on crew competence and their direct implications for occupational safety within a single integrated model, particularly in the context of national shipping companies such as PT. Gelora Per-sada Makmur. Additionally, many existing studies focus on specific contexts such as train-ing vessels, particular regions, or emerging issues like autonomous shipping (Hult, 2023; Chan et al., 2025; Ghosh et al., 2024), thereby limiting their applicability to commercial maritime operations in Indonesia. This study addresses this gap by developing an integrated empirical model that positions safety training and safety knowledge as exogenous variables, crew competence as a mediating variable, and occupational safety onboard as the endoge-nous variable, thereby contributing both theoretically and practically to maritime safety management.

Based on this background, safety training and safety knowledge play a crucial role in enhancing crew competence, which in turn significantly influences occupational safety onboard. Therefore, PT. Gelora Persada Makmur must improve the quality, consistency, and accessibility of its safety training programs while ensuring that all crew members possess adequate knowledge of safety procedures and emergency response. Strengthening these as-pects is essential for fostering a safer working environment and minimizing operational risks in maritime activities.

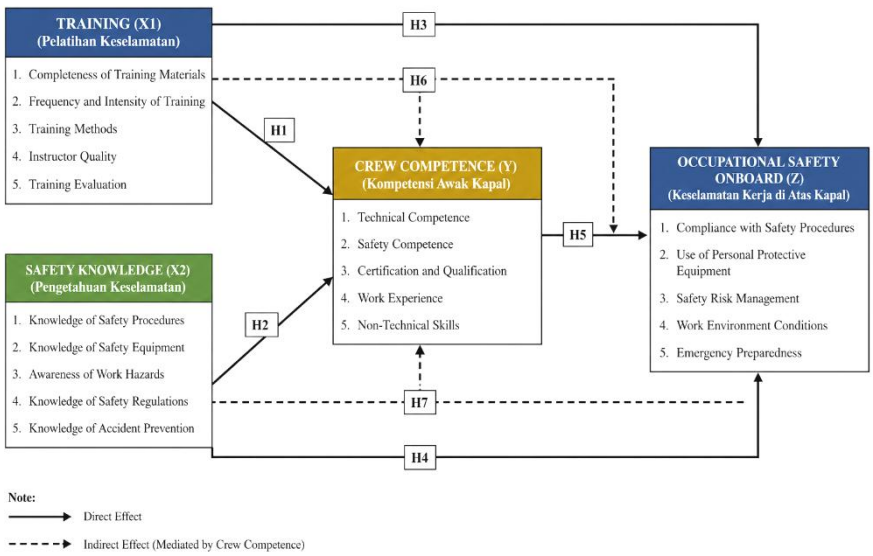

Figure 1. Conceptual Framework

METHOD

This study adopts a quantitative research design using a survey approach. Quantita-tive research applies a structured, systematic, and measurable data analysis process support-ed by statistical techniques to derive objective conclusions (Sekaran & Bougie, 2020). The survey method employed in this study is non-interventional, meaning that no experimental treatment is administered to the respondents; instead, data are collected through structured questionnaires. Furthermore, this research is classified as a case study, as it focuses on a single organization—PT. Gelora Persada Makmur—within a specific time frame, thereby enabling the collection of more homogeneous and context-specific data relevant to the re-search objectives.

The population of this study comprises all crew members involved in ship opera-tions, with a particular focus on those directly working onboard. The sample consists of 100 crew members drawn from four vessels—MV. Lascombes, TB. Five Star, MV. Gruad Larose, and TB. Bintang Mj—with 25 respondents from each vessel. The sampling tech-nique employed is saturated sampling (census sampling), in which all members of the popu-lation are included as research participants (Sugiyono, 2017). This approach is appropriate given the relatively small and accessible population, ensuring comprehensive representation and enhancing the generalizability of findings within the studied context.

The collected data were analyzed using SmartPLS 4 to facilitate efficient and accu-rate statistical processing. The data analysis procedure began with editing, which involved verifying the completeness and consistency of respondents' answers, followed by coding, where responses were systematically categorized to enable effective tabulation and analysis. Through these procedures, the study aims to examine the effect of safety training and safety knowledge on crew competence and their implications for occupational safety onboard at PT. Gelora Persada Makmur.

RESULTS AND DISCUSSION

Results

This study was conducted using a survey method with a questionnaire distributed via Google Forms, resulting in 100 valid respondents. Based on respondent characteristics, the majority were male (95%), while females accounted for 5%. In terms of age distribution, most respondents were between 20–30 years (37%), followed by those above 41 years (32%) and those aged 31–40 years (31%). Regarding educational background, the largest proportion of respondents held S1/ANT.2/ATT.2 qualifications (39%). Based on work experience, most respondents had more than 2 years of experience (70%). In terms of job position, the most common role among respondents was Chief Officer (15%).

Result Outer Model

Overall, the outer model evaluation indicates that all indicators across the variables—Training (X1), Safety Knowledge (X2), Crew Competence (Y), and Occupational Safety (Z)—have outer loading values greater than 0.7, thereby satisfying the criteria for convergent validity. The most dominant dimensions for each variable are training methods (X1), hazard awareness (X2), technical competence (Y), and safety risk management (Z). However, several dimensions such as training material completeness, knowledge of safety procedures, certification, and procedural compliance still require improvement to achieve optimal performance.

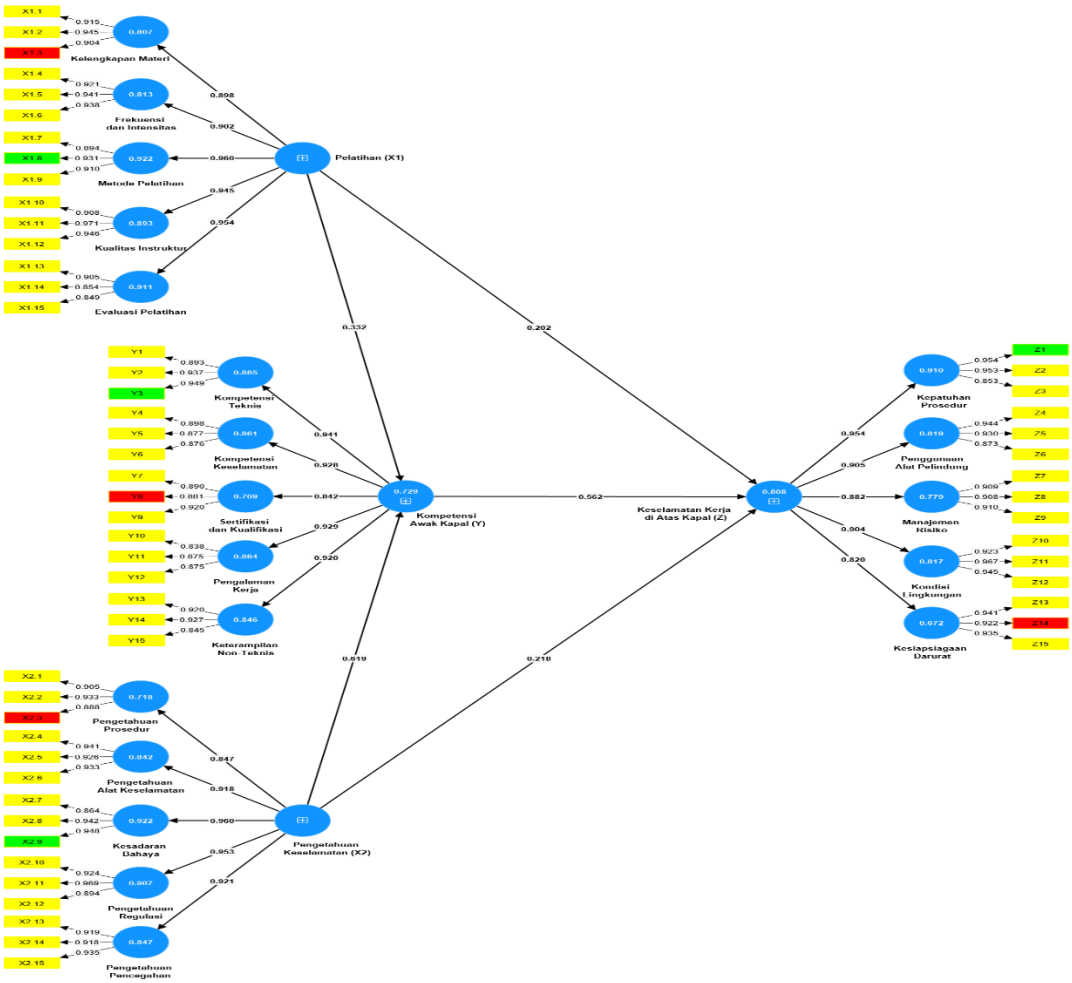

Figure 2. Result Outer Model

Table 1. Result Reliability

Variable	AVE	Cronbach's Alpha	Composite Reliability	Remarks
Training (X1)	0.728	0.973	0.976	Valid & Reliable
Safety Knowledge (X2)	0.722	0.972	0.975	Valid & Reliable
Crew Competence (Y)	0.665	0.964	0.967	Valid & Reliable
Occupational Safety (Z)	0.682	0.966	0.970	Valid & Reliable

The discriminant validity results confirm that the model meets the required criteria based on cross-loading, Fornell-Larcker, and HTMT values (< 0.90), indicating that each construct is empirically distinct from the others. Furthermore, all variables have Average Variance Extracted (AVE) values greater than 0.5, demonstrating good validity. Reliability testing also shows that Cronbach's Alpha values exceed 0.6 and Composite Reliability values exceed 0.7, confirming that all constructs are reliable. Therefore, the measurement model is both valid and reliable, making it suitable for hypothesis testing.

The evaluation of the outer model confirms that all measurement indicators meet the required criteria for validity and reliability, indicating that the constructs used in this study are statistically sound and well-defined. All indicators demonstrate outer loading values above the recommended threshold of 0.7, thereby establishing strong convergent validity. In addition, the Average Variance Extracted (AVE) values for all variables exceed 0.5, further supporting the adequacy of the measurement model. The reliability of the constructs is also well-established,

as evidenced by Cronbach's Alpha values above 0.6 and Composite Reliability values above 0.7, indicating high internal consistency among the indicators.

Furthermore, discriminant validity is confirmed through multiple approaches, including cross-loading, Fornell-Larcker criterion, and HTMT ratios below 0.90, ensuring that each construct is empirically distinct from the others. These findings imply that the measurement model is robust and capable of accurately capturing the theoretical constructs of training, safety knowledge, crew competence, and occupational safety. Overall, the outer model provides a strong foundation for subsequent structural analysis, ensuring that the relationships tested in the inner model are based on reliable and valid measurements.

Inner Model Results

Table 2. Inner Model Summary

Variable	R-Square	Adjusted R-Square	R^2 Category	Q^2 Predictive Relevance	Q^2 Category
Crew Competence (Y)	0.729	0.726	Moderate–Strong	0.480	Strong
Occupational Safety (Z)	0.808	0.805	Strong	0.544	Strong

The inner model analysis demonstrates that the research model has strong explanatory power in describing relationships among latent variables. The R-Square (R^2) value for Crew Competence (Y) is 0.729 (moderate to strong), indicating that 72.9% of the variance is explained by Training and Safety Knowledge. Meanwhile, Occupational Safety (Z) has an R^2 value of 0.808 (strong), meaning that 80.8% of its variance is explained by Training, Safety Knowledge, and Crew Competence.

The predictive relevance (Q^2) results show values greater than zero and fall within the strong category, with 0.480 for Crew Competence and 0.544 for Occupational Safety. This indicates that the model has strong predictive capability and is appropriate for hypothesis testing. Overall, the structural model is robust, relevant, and capable of explaining the relationships among variables in this study.

Hypothesis Testing

The structural model was evaluated by examining the significance of relationships using the bootstrapping method (Ghozali, 2016). Hypotheses are accepted when the t-statistic exceeds 1.64 and the p-value is less than 0.05. The results of hypothesis testing using SmartPLS 4.0 are presented in Figure 2.

Table 2. Hypothesis Testing Results (Direct and Indirect Effects)

Hypothesis	Relationship	Original Sample (O)	T-Statistics	P-Values	Conclusion
H1	Training (X1) → Crew Competence (Y)	0.332	3.730	0.000	Positive & Significant
H2	Safety Knowledge (X2) → Crew Competence (Y)	0.619	7.784	0.000	Positive & Significant
H3	Training (X1) → Occupational Safety (Z)	0.202	1.680	0.048	Positive & Significant
H4	Safety Knowledge (X2) → Occupational Safety (Z)	0.218	2.142	0.017	Positive & Significant
H5	Crew Competence (Y) → Occupational Safety (Z)	0.562	3.225	0.001	Positive & Significant

Hypothesis	Relationship	Original Sample (O)	T-Statistics	P-Values	Conclusion
H6	Training (X1) → Crew Competence (Y) → Occupational Safety (Z)	0.186	1.902	0.030	Positive & Significant
H7	Safety Knowledge (X2) → Crew Competence (Y) → Occupational Safety (Z)	0.348	3.372	0.000	Positive & Significant

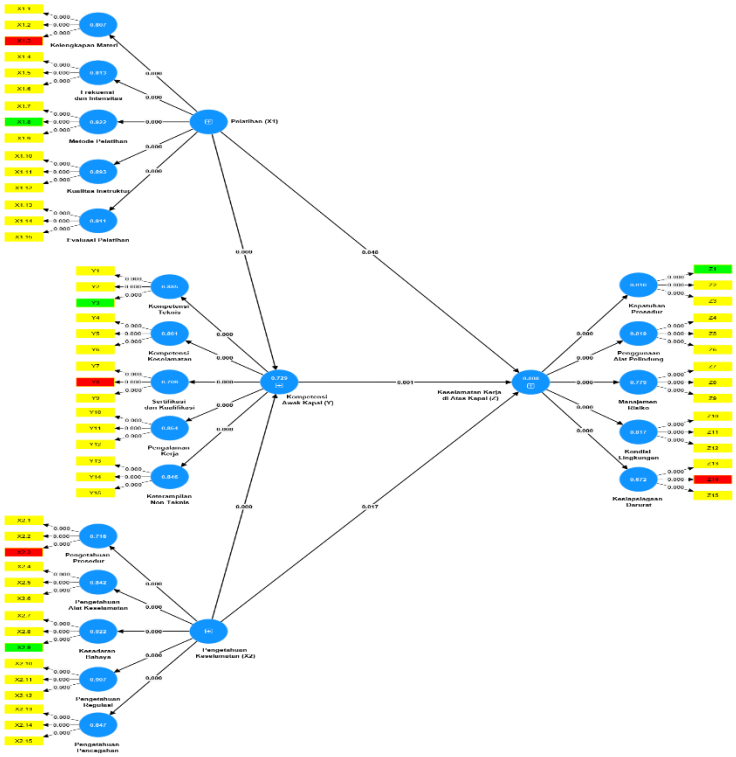

Figure 3. Path Coefficient Results (Bootstrapping)

The results of the inner model analysis demonstrate that the structural model possesses strong explanatory and predictive power. The R-Square values indicate that crew competence is substantially explained by training and safety knowledge, while occupational safety is strongly influenced by training, safety knowledge, and crew competence. Specifically, the R^2 value of 0.729 for crew competence and 0.808 for occupational safety suggest that the model has moderate to strong explanatory capability. Additionally, the Q^2 values for both endogenous variables exceed 0.35, confirming strong predictive relevance and indicating that the model performs well in predicting observed data.

Moreover, the hypothesis testing results reveal that all proposed relationships, both direct and indirect, are positive and statistically significant. Crew competence emerges as a key mediating variable that strengthens the effects of training and safety knowledge on occupational safety. These findings highlight the importance of integrating training and knowledge development with competency enhancement to achieve optimal safety outcomes. Overall, the inner model confirms that the proposed theoretical framework is empirically supported, providing meaningful insights into how organizational interventions can improve safety performance in maritime operations.

Discussion

H1: The Effect of Training on Crew Competence

The results indicate that training has a positive and statistically significant effect on crew competence, as evidenced by a t-statistic of 3.730 (> 1.64), a p-value of 0.000 (< 0.05), and a path coefficient of 0.332. This finding suggests that training contributes 33.2% to the improvement of crew competence, thereby supporting H1. The magnitude and direction of the coefficient confirm that structured training programs play a meaningful role in enhancing the technical and operational capabilities of maritime personnel.

These findings imply that effective training programs, particularly those incorporating simulation-based learning and hands-on practice, significantly strengthen crew readiness and decision-making abilities in real-world scenarios. Training enhances both technical proficiency and confidence, which are essential for safe and efficient ship operations. This result is consistent with prior studies emphasizing the critical role of competency-based training in maritime contexts, including Suprapti (2024), Nurahaju and Utami (2020), Kamis et al. (2020), Phanphichit and Bartusevičienė (2024), Hult (2023), and Gumelar et al. (2021), all of whom highlight training as a key determinant of crew competence and safety performance.

H2: The Effect of Safety Knowledge on Crew Competence

The findings reveal that safety knowledge has a strong, positive, and significant effect on crew competence, with a t-statistic of 7.784, a p-value of 0.000, and a path coefficient of 0.619. This indicates that safety knowledge contributes 61.9% to crew competence, making it the most influential predictor in the model. Therefore, H2 is supported, demonstrating that knowledge-based factors play a dominant role in competency development.

This result underscores the importance of hazard awareness, procedural understanding, and risk mitigation knowledge in shaping both technical and behavioral competence. Crew members with high safety literacy are more capable of responding effectively to emergencies and adhering to operational standards. These findings align with previous research by Dewan et al. (2024), Shi et al. (2024), Kamis et al. (2020), Kurniawan et al. (2023), Chan et al. (2019), and Ghosh et al. (2024), which collectively emphasize that safety knowledge is foundational to competency formation and accident prevention in maritime operations.

H3: The Effect of Training on Occupational Safety Onboard

The results show that training has a positive and significant direct effect on occupational safety onboard, with a t-statistic of 1.680 (> 1.64), a p-value of 0.048 (< 0.05), and a path coefficient of 0.202. This suggests that training contributes 20.2% to improving workplace safety, thus supporting H3. Although the effect size is relatively moderate, it remains statistically meaningful.

These findings indicate that training functions as a preventive mechanism by enhancing awareness, preparedness, and compliance with safety procedures. Simulation-based emergency training and structured safety programs contribute to improved risk management practices. This is consistent with prior studies by Nurahaju and Utami (2020), Kamis et al. (2020), Phanphichit and Bartusevičienė (2024), Dipta et al. (2023), Hult (2023), and Sumantri and Widanti (2023), which highlight the role of training in strengthening maritime safety culture and reducing workplace accidents.

H4: The Effect of Safety Knowledge on Occupational Safety Onboard

The analysis demonstrates that safety knowledge has a positive and significant effect on occupational safety, with a t-statistic of 2.142, a p-value of 0.017, and a path coefficient of 0.218. This indicates that safety knowledge contributes 21.8% to workplace safety, thereby supporting H4. The results confirm that cognitive understanding of safety procedures directly influences safe work behavior.

This finding highlights that individuals with strong safety knowledge are more likely to comply with standard operating procedures and proactively mitigate risks. Safety awareness

enhances vigilance and supports consistent implementation of safety measures. These results are in line with studies by Dewan et al. (2024), Shi et al. (2024), Chan et al. (2019), Kurniawan et al. (2023), Mišković et al. (2022), and Kamis et al. (2020), all of which confirm that safety knowledge significantly improves safety performance in maritime environments.

H5: The Effect of Crew Competence on Occupational Safety Onboard

The findings indicate that crew competence has a strong, positive, and significant effect on occupational safety, with a t-statistic of 3.225, a p-value of 0.001, and a path coefficient of 0.562. This suggests that competence contributes 56.2% to workplace safety, making it a key determinant in the model. Therefore, H5 is accepted.

This result confirms that both technical and non-technical competencies, including decision-making, teamwork, and situational awareness, are crucial in ensuring safe operations onboard. Competent crew members are better equipped to identify hazards and implement effective control measures. This finding is supported by Shi et al. (2024), Kurniawan et al. (2023), Gumelar et al. (2021), Sulistiana and Rachman (2023), Kuzu (2025), and Ghosh et al. (2024), who emphasize competence as a central factor in maritime safety performance.

H6: The Indirect Effect of Training on Occupational Safety through Crew Competence

The results reveal that training has a positive and significant indirect effect on occupational safety through crew competence, with a t-statistic of 1.902, a p-value of 0.030, and an indirect coefficient of 0.186. This indicates that training contributes 18.6% to safety through competence, thus supporting H6. The findings confirm the mediating role of competence.

This suggests that training enhances safety outcomes primarily by first improving crew competence. Competency development enables more effective application of safety procedures and risk management practices. These findings are consistent with Prayogo et al. (2025), Suprapti (2024), Kamis et al. (2020), Chan et al. (2025), Mišković et al. (2022), and Nurahaju and Utami (2020), which emphasize that training effectiveness is maximized when it translates into practical competencies.

H7: The Indirect Effect of Safety Knowledge on Occupational Safety through Crew Competence

The analysis shows that safety knowledge has a positive and significant indirect effect on occupational safety through crew competence, with a t-statistic of 3.372, a p-value of 0.000, and a coefficient of 0.348. This indicates a contribution of 34.8%, which is higher than its direct effect, thus supporting H7. This highlights the strong mediating role of competence.

These findings suggest that safety knowledge becomes more impactful when translated into practical competencies. Competence acts as a mechanism that transforms knowledge into safe behavior and effective risk management. This is supported by Dewan et al. (2024), Shi et al. (2024), Kurniawan et al. (2023), Chan et al. (2019), Kamis et al. (2020), and Ghosh et al. (2024), all of which emphasize the integration of knowledge and competence as essential for achieving optimal safety performance in maritime operations.

CONCLUSION

The findings demonstrate that both training and safety knowledge have positive and significant effects on crew competence. Training, particularly through the training method dimension (0.960), highlights the importance of practical approaches such as simulations and hands-on exercises in enhancing technical and operational capabilities. This is supported by a t-statistic of 3.730 (>1.64), a p-value of 0.000 (<0.05), and a path coefficient of 0.332, indicating a contribution of 33.2%. In contrast, safety knowledge exerts a stronger influence, with the hazard awareness dimension (0.960) emerging as the most dominant factor. The statistical

results (t = 7.784; p = 0.000; β = 0.619) indicate that safety knowledge contributes 61.9% to crew competence, suggesting that a deep understanding of workplace risks and preventive measures is fundamental in shaping both technical proficiency and safe work be-havior.

Furthermore, both training and safety knowledge also have direct positive and signif-icant effects on occupational safety onboard. Training contributes to safety through effective and application-oriented methods, as reflected in a t-statistic of 1.680, a p-value of 0.048, and a coefficient of 0.202 (20.2%). Similarly, safety knowledge enhances workplace safety through improved awareness and adherence to safety procedures, supported by a t-statistic of 2.142, a p-value of 0.017, and a coefficient of 0.218 (21.8%). These results indicate that while both variables play important roles, safety knowledge provides a slightly stronger di-rect contribution to safety outcomes by reinforcing risk awareness and compliance with standard operating procedures.

In addition, crew competence is found to be a key determinant and mediating varia-ble in improving occupational safety onboard. Competence has a strong and significant di-rect effect on safety (t = 3.225; p = 0.001; β = 0.562), indicating a contribution of 56.2%, with technical competence (0.941) as the dominant dimension. Moreover, competence me-diates the relationship between training and safety (β = 0.186; t = 1.902; p = 0.030) as well as between safety knowledge and safety (β = 0.348; t = 3.372; p = 0.000). These findings suggest that training and knowledge are more effective when translated into actual compe-tencies, confirming that competence serves as a critical mechanism through which both fac-tors enhance safety performance. Consequently, strengthening both training quality and safety knowledge, alongside competency development, is essential for achieving optimal occupational safety in maritime operations.

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