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ALAM is committed in inculcating research culture via AJMS, which serves as a platform for authors and researchers to share their knowledge and expertise across the stipulated research areas.

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Foreword by the Ketua Eksekutif for AJMS Volume 5, Issue 1, 2024

It is with immense pride and enthusiasm that I present the latest edition of the ALAM Journal of Maritime Studies (AJMS), Volume 5, Issue 1, 2024. This marks yet another significant milestone in AJMS's journey since its inception in 2017, and a testament to the dedication of our Editorial Board and contributing authors who have made this publication possible.

AJMS continues to serve as a dynamic platform for the dissemination of groundbreaking research and innovative ideas within the maritime domain. This issue features a diverse collection of articles that span a wide range of disciplines, from cutting-edge maritime technologies to advancements in logistics and supply chain management. The breadth and depth of these contributions reflect the growing research culture at ALAM and the increasing interest among our academicians in engaging with meaningful academic pursuits.

As we navigate an era of rapid technological advancements and ever-evolving industry demands, AJMS stands as a beacon of knowledge sharing and intellectual growth. It is a platform where ideas meet application, where challenges inspire solutions, and where innovation fosters progress. This aligns perfectly with ALAM's philosophy of holistic education—Teaching to disseminate knowledge, Research to create knowledge, and Service to share knowledge.

Looking ahead, our aspiration remains steadfast: to see AJMS recognized on the global academic stage through prestigious indexing platforms like Scopus. This recognition would not only elevate AJMS but also place ALAM firmly on the global maritime research map, enabling us to contribute even more meaningfully to the industry and academic communities worldwide.

I invite and encourage researchers from diverse backgrounds academic and industry alike, especially those within the global maritime community to contribute to AJMS. Together, we can ensure a robust, vibrant, and impactful journal that reflects the evolving needs of our industry and society.

Congratulations once again to the Editorial Board and all contributors for their tireless efforts. May AJMS continue to inspire and ignite curiosity for many years to come.

Warm regards,

Ts Dr. Capt. S Manivannan
Chief Executive

ALAM Journal of Maritime Studies

Volume 5, Issue 1, November 2024

TABLE OF CONTENTS

ALAM JOURNAL OF MARITIME STUDIES

ISSN: 2590-4345 e ISSN: 2976-3843 Volume 5 Issue 1 Year 2024

Halal Supply Chain in Malaysia: A Comprehensive Analysis

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Abstract - This review article delves into the intricacies of the halal supply chain in Malaysia, emphasizing its significance, current challenges, and potential advancements. The study aims to provide a comprehensive understanding of the halal supply chain, fostering a scholarly discourse on enhancing its efficiency and compliance. Key insights are drawn from recent literature, offering a critical perspective on the operational and regulatory frameworks governing halal supply chains in Malaysia. Ensuring halal integrity in production involves strict adherence to certified ingredients and processes, while logistical efficiencies are hampered by inadequate infrastructure and Malaysia's tropical climate, highlighting the need for robust cold chain solutions. Regulatory complexities and variable standards across regions pose significant hurdles, emphasizing the importance of international harmonization and mutual recognition of halal certifications. Investing in logistics infrastructure through government incentives and public-private partnerships can significantly reduce delays and spoilage. Additionally, supporting SMEs with financial aid, training, and accessible certification services is crucial for their active participation in the halal market, ultimately strengthening the supply chain's overall competitiveness. This analysis underscores the importance of a coordinated effort to address these challenges and leverage opportunities for a resilient and efficient halal supply chain in Malaysia.

Keywords: Halal Logistics, Halal Supply Chain, Islamic Compliance, Supply Chain Management

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1.0 INTRODUCTION

The halal supply chain in Malaysia is an essential component of the global halal industry, contributing significantly to the country's economy and international trade. The concept of halal extends beyond food products to include pharmaceuticals, cosmetics, and logistics, necessitating rigorous compliance with Islamic laws (Talib, Ali, & Jamaludin, 2008). Malaysia, being a predominantly Muslim country, has established itself as a global hub for halal products, driven by robust regulatory frameworks and certifications (Zailani et al., 2011). This article reviews the current state of the halal supply chain in Malaysia, focusing on key operational challenges and future directions.

The integration of halal principles into the supply chain ensures that products meet the religious and ethical requirements of Muslim consumers. This involves meticulous control over sourcing, production, transportation, and storage processes (Tieman, 2011). Despite these efforts, the halal supply chain faces numerous challenges, including logistical inefficiencies, lack of standardized practices, and rising operational costs (Kamaruddin et al., 2012).

Efficient management of the halal supply chain is critical for maintaining the integrity and trust of halal-certified products. This includes the adoption of advanced technologies and practices such as blockchain for traceability and cold chain logistics to ensure product safety (Haleem & Khan, 2017). The following sections will delve deeper into the components of the halal supply chain in Malaysia, the challenges faced, and potential solutions to enhance its effectiveness.

2.0 HALAL SUPPLY CHAIN IN MALAYSIAN PERSPECTIVES

The Halal supply chain in Malaysia is an intricate system designed to uphold the principles of Halal integrity, ensuring that all products consumed by Muslims are compliant with Islamic laws. This involves a comprehensive approach where every stage, from sourcing raw materials to delivering the final product to consumers, adheres to stringent Halal standards. Malaysia, known for its strong Halal certification processes, has established a sophisticated Halal supply chain that serves as a model for other countries (Halal Development Corporation, n.d.).

The term "Halal" refers to anything that is permissible or lawful according to traditional Islamic law (Shah, 2020). It is often used to describe food and drinks that Muslims are allowed to consume under Islamic dietary guidelines. The opposite of Halal is "Haram," which refers to anything that is forbidden under Islamic law (Khan, 2018). A supply chain encompasses all the steps involved in delivering a product from the supplier to the customer, including production, handling, storage, and delivery. Effective supply chain management ensures efficiency and quality control at each stage (Christopher, 2016). Table 1 below shows that definition of Halal of Islamic Law, conventional, ISO and other related.

Table 1. Definition of Halal of Islamic Law, conventional, ISO and other related

Aspect	Definition	Source
Definition under Islamic Law	Permissible or lawful in traditional Islamic law, often used to describe food and drinks that Muslims are allowed to consume under Islamic dietary guidelines.	Traditional Islamic Law Texts and Scholars
Conventional Definition	Generally, refers to anything that is lawful or permitted.	General English Dictionaries
ISO Definition	As per ISO 17065, Halal certification is a process that ensures the features and quality of the products according to the rules established by the Islamic Council.	ISO 17065:2012
Other Related Definitions	In finance, Halal refers to financial practices that comply with Sharia law, such as prohibition of interest (Riba) and speculative transactions (Gharar).	Islamic Finance Principles, AAOIFI Standards

The integration of Halal principles with modern supply chain practices is crucial for maintaining consumer trust and ensuring the authenticity of Halal products. According to a study by Zainuddin et al. (2019), effective implementation of Halal certification and labeling processes significantly enhances the performance of the Halal supply chain. The study highlights that the current practices in Malaysia's Halal certification system are essential for maintaining Halal integrity throughout the supply chain. Fig. 1 shows the illustration of the Halal Supply Chain Implementation Framework, adapted from Zainuddin et al. (2019).

Another research by Arshad et al. (2018) points out that ensuring Halal integrity across the supply chain is crucial for avoiding risks of contamination and adulteration. The study emphasizes the need for comprehensive Halal integrity assurance across all stages of the supply chain to maintain consumer confidence in Halal products. Fig. 2 shows the illustration of the Conceptual Model of Halal Supply Chain Management, adapted from Arshad et al. (2018).

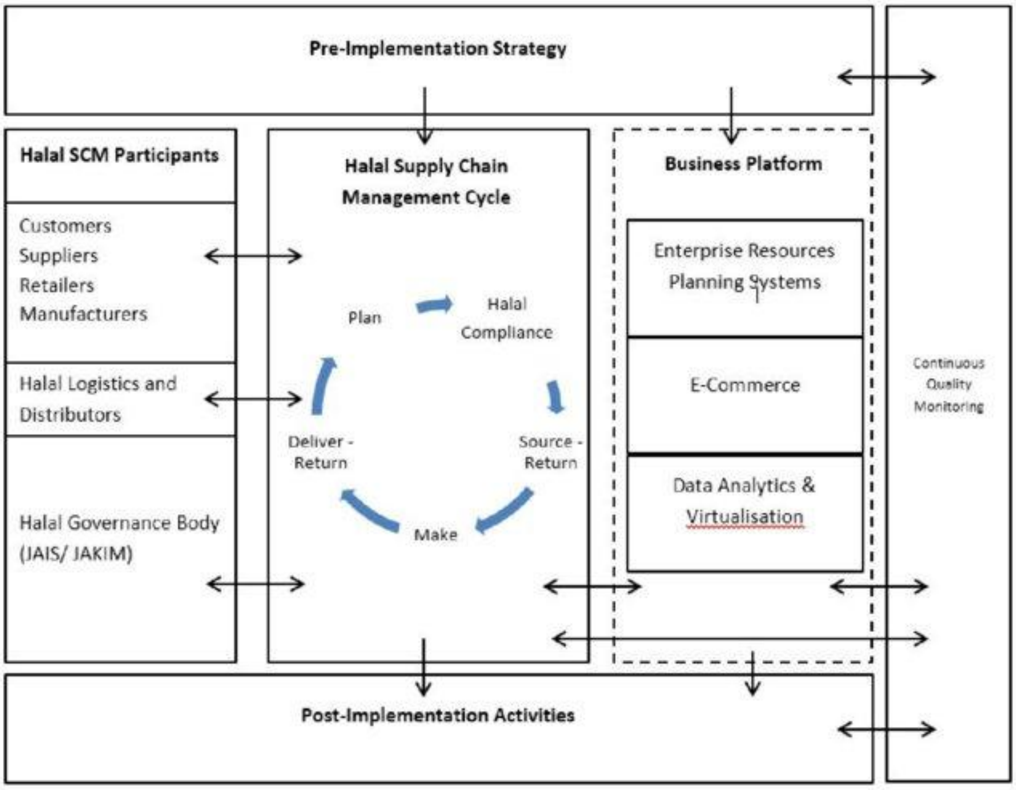

Fig. 1. Halal Supply Chain Implementation Framework.
Source: Hassan et.al, 2017.

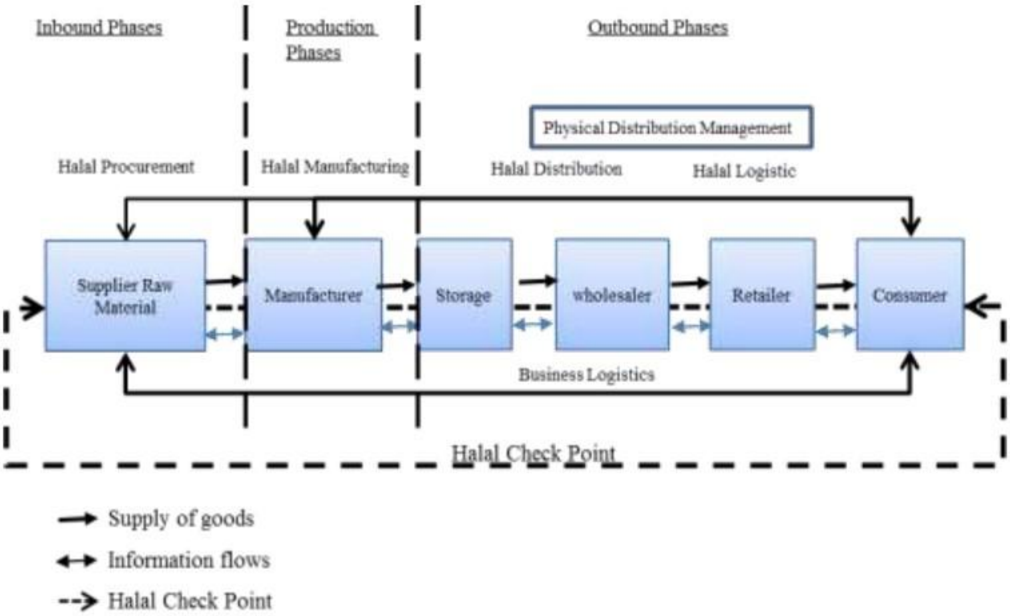

Fig. 2. Conceptual Model of Halal Supply Chain Management
Source: Mohamed et al, 2016.

2.1 Components of the Halal Supply Chain

The halal supply chain is an intricate system that ensures the integrity and compliance of products with halal standards from the initial stages of raw material sourcing to the final delivery to the consumer. Each stage of this supply chain must adhere to strict guidelines to ensure that the products meet the religious and ethical requirements of halal consumers. The process begins with the sourcing of raw materials, which must come from certified halal sources. For instance, in the case of meat products, animals must be slaughtered according to Islamic laws, ensuring that the animal is healthy at the time of slaughter, and that it is slaughtered by a Muslim who invokes the name of Allah (God) before the act. Plant-based raw materials must also be free from contamination with non-halal substances, such as alcohol or products derived from animals not slaughtered according to halal practices. The halal supply chain encompasses various stages, from raw material sourcing to end-consumer delivery. Each stage requires stringent adherence to halal standards to maintain product integrity (Tieman, van der Vorst, & Che Ghazali, 2012).

Once the raw materials are sourced, the next critical stage is production and processing. This stage involves transforming raw materials into finished products while maintaining Halal compliance. It is essential that the production environment is clean and free from any contaminants that could compromise the Halal status of the products. This includes using dedicated equipment and facilities for Halal products or implementing thorough cleaning procedures if the equipment is shared with non-Halal products. The personnel involved in the production process must also follow strict hygiene and handling protocols to ensure that the products remain uncontaminated. Additionally, the production processes themselves must avoid the use of non-Halal additives, such as certain preservatives or flavor enhancers derived from non-Halal sources (Halim & Salleh, 2019).

Packaging, storage, and transportation are equally crucial components of the Halal supply chain. Packaging materials must be Halal and protect the product from contamination. Clear labeling indicating that the product is Halal-certified helps consumers make informed choices. During storage, Halal products must be kept separate from non-Halal items to avoid cross-contamination, which often requires dedicated storage facilities or strict protocols to clean shared spaces. Similarly, transportation of Halal products should be managed to maintain their Halal status, often necessitating dedicated vehicles or rigorous cleaning protocols. The distribution network must ensure that Halal products are handled correctly and displayed appropriately in retail environments, preventing any compromise to their Halal integrity. Ultimately, the delivery of the product to the end consumer must ensure that the product's Halal status is preserved through all stages of handling and sale, whether through physical stores or online platforms (Ahmad & Hassan, 2020).

By maintaining strict adherence to halal standards at every stage of the supply chain, businesses can ensure that their products meet the expectations and religious requirements of halal consumers. This meticulous process not only builds consumer trust but also opens opportunities in the growing global market for halal products. The comprehensive nature of the halal supply chain underscores the importance of maintaining product integrity from farm to fork, ensuring that every step complies with the rigorous standards set forth by halal certification bodies. This dedication to quality and compliance is essential for the success and credibility of halal products in the marketplace.

2.2 Raw Material Sourcing

Sourcing halal-compliant raw materials is the cornerstone of ensuring the integrity of halal products. This process begins with selecting suppliers who are certified by recognized halal certification bodies. These certifications are crucial as they affirm that the raw materials meet stringent halal standards, ensuring that they do not compromise the halal integrity of the end products. According to Noordin et al. (2009), the certification bodies conduct rigorous inspections and verifications to ascertain that the suppliers adhere to Islamic dietary laws. This includes verifying the source of the materials, the methods of procurement, and ensuring that there is no cross-contamination with non-halal substances. The importance of this initial step cannot be overstated, as it sets the foundation for the entire halal production process.

The certification process for halal compliance is comprehensive and demanding. Suppliers are required to undergo thorough training to understand the principles and practices of halal production. Ngah et al. (2014) emphasize that this training is essential for suppliers to maintain the high standards expected in the halal industry. Additionally, regular audits are conducted to ensure ongoing compliance. These audits examine every aspect of the supplier's operations, from sourcing and handling to storage and transportation of raw materials. The objective is to maintain a continuous and uncompromised halal supply chain. This meticulous approach not only assures consumers of the halal integrity of the products but also helps build trust and credibility in the marketplace, fostering a loyal customer base that values adherence to halal standards.

2.3 Production and Processing

In the production stage, maintaining halal compliance is a meticulous process that begins with the selection of ingredients. Halal-certified ingredients are fundamental to ensuring that the final product adheres to Islamic dietary laws. This certification process involves rigorous checks to verify that the ingredients do not contain any components derived from haram (forbidden) sources such as pork or alcohol. Additionally, ingredients must not be contaminated by such sources at any stage of the supply chain. To facilitate this, producers often rely on suppliers who are themselves certified halal, creating a trusted network of compliant sources (Bonne & Verbeke, 2008). This initial step is crucial because the use of non-halal ingredients would render the entire production process void of halal status, making it unacceptable for Muslim consumers.

Furthermore, the production facilities where halal products are processed must also adhere to stringent standards. These facilities need to be certified halal to ensure that all equipment and processes involved do not compromise the halal integrity of the products. This involves a comprehensive inspection of the production line to confirm that there is no cross-contamination with non-halal substances. For instance, equipment used for producing halal foods must not have been used for processing non-halal foods, or it must be thoroughly cleaned and sanitized according to halal guidelines if it has been previously used for non-halal purposes. Maintaining hygiene standards is another critical aspect, as cleanliness is a core principle in Islamic teachings. This includes regular cleaning schedules, proper waste disposal, and ensuring that all workers adhere to hygiene practices, thereby preventing any form of contamination (Fischer, 2011). By following these protocols, producers can maintain the halal status of their products, ensuring they meet the religious requirements of Muslim consumers and gain their trust and loyalty.

2.4 Logistics and Transportation

In the realm of logistics and transportation, maintaining halal integrity is paramount. This involves utilizing dedicated halal transportation systems designed specifically to prevent cross-contamination with non-halal products. These systems often include segregated compartments within transport vehicles, ensuring that halal products are kept separate from non-halal items throughout the journey. For instance, a truck used to transport halal meat should not be used for transporting pork or alcohol, or it must be thoroughly cleaned and sanitized according to halal standards if it has been used for such purposes. The adherence to these guidelines ensures that the products remain halal from the point of production to the destination, thus preserving their religious compliance and consumer trust (Tieman, 2011).

Cold chain logistics play a particularly crucial role in the transportation of perishable halal products. The cold chain ensures that products such as meat, dairy, and other perishables are kept at consistent temperatures to maintain their quality and safety. This is vital not only for preventing spoilage but also for maintaining the halal status of these products. Any break in the cold chain could result in contamination or spoilage, compromising the halal integrity. Hence, specialized cold storage units and refrigerated vehicles are utilized to ensure that perishable halal products remain at the required temperatures throughout the supply chain. This meticulous management of temperature and conditions is essential for preventing any potential breaches of halal standards, ensuring that the products arrive at their destination in a state that is both safe to consume and compliant with halal regulations (Zulfakar, Anuar, & Ab Talib, 2014). By maintaining rigorous controls over logistics and transportation, the halal status of products is preserved, reinforcing the reliability of halal certification for consumers.

2.5 Storage and Warehousing

In the context of storage and warehousing, maintaining the halal status of products necessitates strict segregation practices. Halal products must be stored separately from non-halal products to prevent any form of cross-contamination. This segregation is typically achieved through the use of dedicated storage areas within warehouses that are clearly marked and physically separated. Such measures ensure that halal products do not meet haram (forbidden) substances, thereby preserving their halal integrity. For instance, a warehouse storing halal food products must have designated sections that are exclusively used for these products, ensuring that even indirect contamination from non-halal products is avoided. Regular audits and inspections by halal certification bodies are essential to ensure that these segregation practices are consistently followed, and that the facility adheres to halal standards (Awan, Siddiquei, & Haider, 2015).

Proper storage conditions are equally critical in preserving both the quality and halal status of products. This includes maintaining appropriate temperature controls to prevent spoilage, which is particularly important for perishable items like meat and dairy products. Halal storage facilities must be equipped with reliable refrigeration and climate control systems to ensure that these products remain in optimal condition throughout their storage period. Cleanliness is another key factor, as Islamic principles emphasize the importance of hygiene. Storage areas must be kept clean and free from contaminants, with regular cleaning schedules and strict hygiene protocols in place. This includes ensuring that all equipment and surfaces are sanitized according to halal guidelines. By adhering to these stringent conditions, warehouses can maintain the halal status of stored products, ensuring they remain safe for consumption and compliant with halal standards from storage to distribution (Talib & Hamid, 2014). These efforts in storage and warehousing are essential components of a holistic halal supply chain, reinforcing consumer confidence in the integrity of halal-certified products.

3.0 CHALLENGES IN THE HALAL SUPPLY CHAIN

Despite the structured framework, the halal supply chain in Malaysia faces several challenges that hinder its efficiency and reliability.

3.1 Regulatory and Certification Issues

The complexity and variability of halal certification standards across different regions present significant challenges for businesses involved in international trade. While JAKIM (Department of Islamic Development Malaysia) is renowned for its comprehensive halal certification guidelines, the lack of a universally accepted standard complicates matters. Each country may have its own halal certification bodies with distinct requirements and processes, leading to discrepancies and misunderstandings. For instance, what is deemed halal in one country might not be recognized as such in another due to differences in interpretation of Islamic dietary laws or specific procedural requirements. This lack of uniformity requires businesses to navigate a complex landscape of multiple certification authorities, each with their own set of rules, thereby increasing the administrative burden and the potential for compliance issues (Zailani et al., 2011).

These inconsistencies in certification processes can also lead to operational delays and increased costs for businesses. Obtaining multiple certifications to satisfy different regional requirements can be time-consuming and expensive, often involving extensive documentation, inspections, and modifications to production processes. These added costs can be prohibitive, particularly for small and medium-sized enterprises (SMEs) attempting to enter the global halal market. Moreover, delays in certification approval can disrupt supply chains and lead to missed market opportunities. For example, if a shipment is held up due to pending certification in the destination country, it can result in spoilage of perishable goods, financial losses, and damaged business relationships. Such challenges highlight the need for greater harmonization and mutual recognition of halal certification standards internationally, which would facilitate smoother trade flows and reduce the compliance burden on businesses, ultimately benefiting both producers and consumers (Ab Talib & Chin, 2018).

3.2 Technological Barriers

The adoption of advanced technologies within the halal supply chain remains relatively limited, presenting significant barriers to enhancing traceability and transparency. Technologies such as blockchain and the Internet of Things (IoT) offer promising solutions by enabling real-time monitoring and recording of product information throughout the supply chain. Blockchain technology, for instance, can provide an immutable ledger of transactions and product histories, ensuring that halal compliance is maintained at every stage from production to distribution. Similarly, IoT devices can monitor environmental conditions, such as temperature and humidity, ensuring that halal products are stored and transported under optimal conditions. However, implementing these technologies requires substantial investment in infrastructure and specialized expertise to manage and operate these systems effectively (Ali & Suleiman, 2016).

For many small and medium enterprises (SMEs) in Malaysia, the financial and technical resources required to adopt such advanced technologies are often beyond reach. SMEs play a crucial role in the halal supply chain, but their limited access to capital and technological know-how creates significant gaps in the system. Without the ability to invest in blockchain or IoT, these businesses may struggle to meet the growing demand for transparency and traceability from both regulators and consumers. This lack of technological integration can result in inefficiencies, increased risks of non-compliance, and potential loss of market trust. Moreover, the technological divide exacerbates the challenge of maintaining consistent halal standards across the supply chain, as smaller players may be unable to provide the same level of assurance as larger, tech-enabled enterprises. Addressing these technological barriers requires targeted support, such as government incentives, training programs, and collaborative efforts to make advanced technologies more accessible and affordable for SMEs, thereby strengthening the overall integrity and efficiency of the halal supply chain (Aziz & Chok, 2013).

3.3 Logistical Inefficiencies

Logistical inefficiencies present a formidable challenge to the halal supply chain, particularly in Malaysia. One of the primary issues is the inadequate infrastructure and transportation networks, which hinder the efficient movement of goods. Many regions may lack the necessary roads, ports, and logistics hubs to facilitate smooth and timely transportation, leading to bottlenecks and delays. For halal products, especially those that are perishable, such delays can be critical. The tropical climate of Malaysia exacerbates this problem, as the high temperatures and humidity can quickly spoil perishable items like meat and dairy products if they are not transported under proper conditions. Therefore, robust cold chain solutions are essential to maintain the integrity and quality of these products throughout the supply chain (Zulfakar et al., 2014).

However, the implementation of effective cold chain logistics comes with its own set of challenges. These systems require significant investment in refrigeration technology, insulated transport vehicles, and skilled personnel to manage and monitor the cold chain processes. For many businesses, particularly small and medium-sized enterprises (SMEs), the costs associated with establishing and maintaining a robust cold chain infrastructure can be prohibitive. As a result, inefficiencies in logistics can lead to frequent delays, increased spoilage rates, and higher operational costs. For instance, if a shipment of halal meat is delayed and the refrigeration units fail to maintain the required temperature, the entire consignment may be rendered non-halal due to spoilage, leading to financial losses and reputational damage. Additionally, these inefficiencies can disrupt the overall supply chain, making it difficult for businesses to meet consumer demands and regulatory standards consistently. Addressing these logistical challenges requires coordinated efforts to improve infrastructure, invest in advanced logistics technologies, and provide support for SMEs to enhance their cold chain capabilities, thereby ensuring the reliability and efficiency of the halal supply chain (Ab Talib, Hamid, & Zulfakar, 2015).

3.4 Cost and Resource Constraints

Implementing and maintaining a halal supply chain involves significant costs and resource constraints, which can be particularly burdensome for businesses. To comply with halal standards, companies must invest in obtaining halal certification, which often involves a comprehensive audit of their processes, ingredients, and supply chain practices. This certification process requires thorough documentation, regular inspections, and adherence to stringent guidelines, all of which incur considerable costs. Additionally, businesses need to invest in continuous training for their staff to ensure that they are knowledgeable about halal requirements and capable of maintaining compliance throughout the production, handling, and distribution stages. This training is crucial for preventing inadvertent breaches of halal standards, which can result in product recalls and damage to the company's reputation (Omar & Jaafar, 2011).

For small and medium-sized enterprises (SMEs), the financial burden of these investments can be prohibitive. Unlike larger companies that may have more substantial financial resources and economies of scale, SMEs often operate with limited budgets and narrower profit margins. The costs associated with halal certification, infrastructure upgrades, and employee training can therefore be a significant barrier to entry into the halal market. This limitation restricts their ability to compete effectively with larger, well-established businesses that can more easily absorb these expenses. Moreover, the need for specialized equipment and facilities, such as dedicated halal production lines and segregated storage areas, further adds to the operational costs. As a result, many SMEs may find it challenging to meet the growing demand for halal products, thereby missing out on lucrative market opportunities. Addressing these cost and resource constraints requires targeted support from governments and industry bodies, such as subsidies for certification costs, grants for infrastructure improvements, and training programs to help SMEs enhance their competitiveness in the halal market (Ngah et al., 2014).

4.0 FUTURE DIRECTIONS AND SOLUTIONS

Addressing the challenges in the halal supply chain requires a multifaceted approach, combining regulatory reforms, technological advancements, and industry collaboration.

4.1 Enhancing Regulatory Frameworks

Enhancing regulatory frameworks to streamline halal certification processes and harmonize standards internationally is critical for reducing complexities and improving efficiency in the halal supply chain. Currently, the lack of uniformity in halal standards across different countries creates significant barriers for businesses engaged in international trade. Each country may have its own set of certification requirements and procedures, leading to duplication of efforts and increased costs. By working towards harmonization of these standards, businesses can benefit from a more straightforward and cohesive certification process. For example, if a product is certified halal by JAKIM in Malaysia, having that certification recognized by other countries' halal bodies without additional scrutiny would greatly simplify international trade. This mutual recognition of halal certifications can reduce administrative burdens, shorten the time to market, and lower operational costs for businesses (Zailani et al., 2017).

Collaborative efforts between JAKIM and international halal bodies are essential to achieve this harmonization. Such collaboration can involve joint development of standardized guidelines, regular dialogues to address differences in interpretation of halal principles, and mutual audits to ensure consistency in certification practices. Establishing global forums or working groups where these bodies can share knowledge, and best practices would facilitate the development of a unified approach to halal certification. Furthermore, leveraging technology to create centralized databases of certified products and companies can enhance transparency and trust among certification bodies, regulators, and consumers. By fostering a collaborative international framework, the halal industry can enhance its credibility, promote global trade, and meet the growing demand for halal products more efficiently. This unified approach not only benefits businesses by easing market entry and expansion but also ensures that consumers worldwide have access to authentic and reliable halal products, reinforcing their confidence in halal certification (Zailani et al., 2017).

4.2 Leveraging Technology

Leveraging technology, particularly blockchain, can revolutionize the halal supply chain by enhancing traceability and transparency. Blockchain technology provides an immutable ledger that records every transaction and movement of products throughout the supply chain. This real-time tracking ensures that all participants in the supply chain, from producers to retailers, can verify the halal status of products at every stage. For instance, blockchain can document the entire journey of halal meat, from slaughterhouses following Islamic practices to the final retail destination, ensuring that no contamination occurs along the way. This level of traceability not only helps in maintaining halal compliance but also builds consumer trust, as customers can access information about the product's origin and handling through secure, tamper-proof records (Tieman, 2011).

In addition to blockchain, the integration of Internet of Things (IoT) devices can significantly enhance the monitoring and control of storage and transportation conditions in the halal supply chain. IoT devices, such as smart sensors and GPS trackers, can continuously monitor critical parameters like temperature, humidity, and location in real-time. For perishable halal products, maintaining specific environmental conditions is crucial to prevent spoilage and ensure compliance with halal standards. For example, IoT-enabled refrigeration units can alert operators if temperatures deviate from the set range, allowing for immediate corrective actions to preserve product integrity. These devices can also provide comprehensive data logs that demonstrate adherence to halal requirements during audits and inspections. By integrating IoT technology, businesses can achieve greater operational efficiency, reduce the risk of non-compliance, and enhance the overall reliability of the halal supply chain (Haleem & Khan, 2017).

Together, blockchain and IoT create a robust technological framework that supports the stringent demands of the halal industry. They provide end-to-end visibility and control, ensuring that halal products remain compliant, safe, and of high quality from production to consumption. These technologies not only help in meeting regulatory requirements but also offer a competitive edge by enhancing consumer confidence and satisfaction in halal products.

4.3 Improving Logistics Infrastructure

Improving logistics infrastructure, especially through the development of robust cold chain solutions, is crucial for enhancing the efficiency and reliability of the halal supply chain. Inadequate infrastructure can lead to significant delays, spoilage of perishable goods, and increased operational costs, which are detrimental to maintaining the halal integrity of products. Investing in advanced cold chain logistics ensures that perishable halal products, such as meat and dairy, are kept at optimal temperatures throughout transportation and storage. This prevents spoilage and contamination, thus preserving the products' halal status and quality. Efficient cold chain systems enable seamless integration from production to final delivery, minimizing the risk of breaches in the halal certification process and ensuring that consumers receive products that meet the stringent halal standards (Zulfakar et al., 2014).

Government incentives and public-private partnerships play a pivotal role in facilitating the development of dedicated halal logistics networks. Governments can offer subsidies, tax breaks, and grants to businesses investing in halal-compliant infrastructure, thereby lowering the financial barriers for small and medium-sized enterprises (SMEs) that might struggle with the high costs of such investments. Additionally, public-private partnerships can bring together the expertise and resources of both sectors to build state-of-the-art logistics facilities. For instance, collaborations between government agencies, halal certification bodies, and private logistics companies can lead to the creation of specialized halal logistics hubs equipped with advanced cold storage facilities, dedicated transport fleets, and rigorous monitoring systems. These hubs can serve as central nodes in the halal supply chain, ensuring that products are efficiently consolidated, stored, and distributed while maintaining compliance with halal standards. Improved infrastructure not only reduces delays and spoilage but also enhances the overall competitiveness of the halal industry by ensuring timely delivery and consistent quality of halal products to global markets. This strategic investment in logistics infrastructure ultimately fosters greater consumer trust and expands market opportunities for halal-certified products.

4.4 Supporting SMEs

Supporting small and medium-sized enterprises (SMEs) is essential to enable their active participation in the halal market. SMEs often face significant cost and resource constraints that can hinder their ability to meet the stringent requirements of halal certification and maintain compliance throughout their operations. To address these challenges, government grants and subsidies can play a crucial role in reducing the financial burden on SMEs. This financial aid can help cover the costs associated with halal certification, such as audit fees, infrastructure modifications, and compliance documentation. Additionally, providing low-interest loans or tax incentives can further ease the financial strain on these businesses, allowing them to invest in necessary improvements without compromising their operational viability (Aziz & Chok, 2013).

Moreover, offering comprehensive training programs and access to halal certification services can significantly enhance the capabilities of SMEs in the halal supply chain. Training programs can equip SME owners and employees with the knowledge and skills needed to understand and implement halal standards effectively. These programs can cover various aspects, including halal food handling, hygiene practices, and regulatory compliance. By improving their understanding of halal requirements, SMEs can better align their operations with these standards, thereby increasing their chances of obtaining and maintaining halal certification. Furthermore, facilitating access to halal certification services, such as by establishing local certification offices or providing online certification platforms, can streamline the certification process for SMEs. This technical support not only helps SMEs overcome resource constraints but also ensures that they can compete on an equal footing with larger companies. Enhancing the participation of SMEs in the halal market through such targeted support measures will strengthen the overall competitiveness and resilience of the halal supply chain in Malaysia, fostering a more inclusive and dynamic industry (Aziz & Chok, 2013).

5.0 DISCUSSION AND CONCLUSION

The halal supply chain in Malaysia is a critical component of the global halal industry, requiring stringent compliance with Islamic principles and efficient management practices. Despite facing challenges such as regulatory complexities, technological barriers, and logistical inefficiencies, there are significant opportunities for improvement. By enhancing regulatory frameworks, leveraging technology, improving logistics infrastructure, and supporting SMEs, Malaysia can further strengthen its position as a global hub for halal products. This review highlights the need for continued research and collaboration to address these challenges and promote the growth of the halal supply chain.

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Comprehensive Analysis of Mental Health and Psychological Well-Being Among Maritime Workers in Malaysia

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Abstract - The mental health and psychological well-being of maritime workers in Malaysia have become critical concerns due to the unique and challenging nature of their work environment. This comprehensive review synthesizes literature from the past seven years to examine the prevalence, associated factors, and effective interventions related to mental health issues among Malaysian maritime personnel. The findings reveal a significant prevalence of anxiety (61%), depression (39%), and stress (28%) among maritime workers. Contributing factors include occupational stressors such as long working hours, isolation, and hazardous conditions, as well as psychosocial barriers like societal stigma and limited access to mental health resources. Economic challenges, including job insecurity and financial stress, and environmental factors, such as poor onboard living conditions, further exacerbate these issues. Effective interventions identified include organizational support, access to mental health services, and psychological interventions like mindfulness and self-compassion training. Policy recommendations include revising the Occupational Safety and Health Act to incorporate mental health provisions and implementing mental health off days to support workers. Enhancing community and social support systems is also crucial. This review underscores the urgent need for targeted mental health strategies and supportive policies to address the unique challenges faced by maritime workers in Malaysia. Future research should continue to explore these areas to develop robust evidence-based practices to enhance the mental well-being of this critical workforce.

Keywords: Maritime Workers, Mental Health, Psychological Well-Being, Occupational Stress, Malaysia

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1.0 INTRODUCTION

The mental health and psychological well-being of maritime personnel have garnered significant attention due to the unique challenges inherent in this profession. Maritime personnel often work in isolated environments, face long periods away from family, and deal with demanding workloads and hazardous conditions. These factors contribute to a heightened risk of mental health issues such as anxiety, depression, and stress. Understanding the mental health landscape of maritime workers, particularly in Malaysia, is crucial for developing effective interventions and policies to support their well-being.

Malaysia, as a key player in the maritime industry, has a substantial workforce engaged in maritime activities, including shipping, aquaculture, and emergency rescue operations. The maritime sector is vital to the nation's economy but poses significant mental health challenges for its workers. Previous studies have highlighted the prevalence of mental health issues among maritime personnel, revealing a concerning trend of psychological distress within this group. For instance, research has shown that maritime personnel in Malaysia experience high levels of anxiety and depression, exacerbated by occupational and environmental stressors(Chan et al., 2021.)

Despite the growing recognition of these issues, there remains a gap in comprehensive research specifically focusing on the mental health and psychological well-being of maritime personnel in Malaysia. This review aims to fill this gap by synthesizing existing literature from the past seven years, examining the prevalence of mental health issues, associated factors, and effective interventions. By doing so, we seek to provide a foundation for future research and inform policy and practice to enhance the mental well-being of maritime workers. This analysis will also highlight the need for targeted mental health interventions and supportive policies tailored to the unique challenges faced by maritime personnel.

2.0 MENTAL HEALTH

2.1 Prevalence of Mental Health Issues

Mental health problems among maritime personnel in Malaysia have been increasingly recognized in recent years. A study by Chan et al. (2021) reported that 30% to 61% of emergency responders, including maritime personnel, develop anxiety issues, while 15% to 39% suffer from depression and 13% to 28% from stress. This indicates a significant burden of mental health disorders within this population.

The prevalence of mental health issues is further compounded by occupational stressors unique to the maritime industry. According to Othman et al., (2023), seafarers face significant psychosocial stressors, which can negatively impact their mental health and well-being. The Malaysian Healthiest Workplace survey also highlighted that more than half of employees, including maritime personnel, experience job-related stress such as burnout and anxiety ((Razak, 2019).

Studies specifically focusing on Malaysian maritime personnel have reported high levels of psychological distress. Samsudin et al. (2021) found that firefighters, including those involved in maritime rescue operations, exhibit significant levels of anxiety, depression, and stress due to their demanding roles. Similarly, (Yeoh, 2023) reported that Malaysian maritime personnel face significant mental health challenges, primarily due to job insecurity and occupational stress.

These findings are consistent with global trends, where maritime personnel often exhibit higher levels of psychological distress compared to other professions. A cross-cultural study by Sugawara et al. (2022) comparing Malaysia with other countries found that Malaysian maritime personnel reported significant mental health issues, similar to their international counterparts. This underscores the need for targeted mental health interventions for this group.

2.2 Factors Associated with Mental Health Issues

Several factors contribute to the high prevalence of mental health issues among maritime personnel in Malaysia. Occupational stressors, including long working hours, isolation, and exposure to hazardous environments, are primary contributors. Othman et al. (2023) identified occupational hazards and risks, human capital skills, onboard living conditions, and governance capacity as key enablers of occupational stress among seafarers.

Psychosocial factors also play a significant role. Berry et al. (2020) found that young people in Malaysia, including maritime personnel, face considerable mental health challenges due to societal stigma, lack of mental health resources, and cultural barriers to seeking help. The same study highlighted that self-compassion, and a sense of control are essential for maintaining mental health during stressful periods, such as the COVID-19 pandemic.

Economic factors, such as job insecurity and financial stress, further exacerbate mental health issues. Jalil et al. (2023)demonstrated that job insecurity is negatively associated with psychological well-being among Malaysian precarious workers, including those in the maritime industry. The study also found that work-life balance mediates this relationship, emphasizing the need for policies that support job security and work-life balance.

Environmental factors, such as poor onboard living conditions, also contribute to mental health issues. A study by Mat Zain & Lee (2022) highlighted that aquaculture workers in Malaysia face significant health complaints and psychological distress due to poor working conditions. These findings suggest that improving living and working conditions can significantly enhance the mental well-being of maritime personnel.

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This review article employs a systematic review methodology to synthesize existing literature on the mental health and psychological well-being of maritime personnel in Malaysia. The research design follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a comprehensive and transparent review process.

3.2 Data Sources and Search Strategy

A comprehensive literature search was conducted across multiple databases, including PubMed, Scopus, PsycINFO, and Google Scholar. The search was limited to studies published within the last seven years (2017-2023) to ensure the relevance and timeliness of the findings. The following keywords were used in various combinations to identify relevant studies:

- Mental health
- Psychological well-being
- Maritime personnel
- Seafarers
- Malaysia
- Occupational stress
- Anxiety
- Depression
- Stress

3.3 Inclusion and Exclusion Criteria

3.3.1 Inclusion Criteria

- Studies published in peer-reviewed journals between 2017 and 2023.
- Research focusing on mental health and psychological well-being of maritime personnel in Malaysia.
- Studies that provide quantitative or qualitative data on the prevalence, associated factors, or interventions related to mental health issues.

3.3.2 Exclusion Criteria

- Studies focusing on non-maritime personnel.
- Research conducted outside Malaysia without relevant comparative insights applicable to the Malaysian context.
- Non-peer-reviewed articles, editorials, commentaries, and opinion pieces.

3.4 Data Extraction and Analysis

Data were extracted from each included study using a standardized extraction form. The extracted data were then synthesized to identify common themes and patterns. Descriptive statistics were used to summarize the prevalence rates of mental health issues, and qualitative synthesis was employed to analyse the associated factors and interventions.

4.0 RESULT AND ANALYSIS

Table 1 shows the prevalence of mental health issues among maritime personnel in Malaysia is notably high. According to Chan et al. (2021), a study involving 11,356 employees, including maritime personnel, found that 61% experienced anxiety, 39% suffered from depression, and 28% reported significant stress levels. This indicates a considerable burden of mental health disorders within this population. Similarly, Samsudin et al. (2021) reported that 30% to 61% of emergency responders, including those involved in maritime rescue operations, developed anxiety issues, while 15% to 39% experienced depression and 13% to 28% suffered from stress.

In addition, Razak (2019) highlighted that job-related stress, including burnout, anxiety, and depression, significantly affects maritime personnel. The study underscored the importance of workplace interventions to mitigate these mental health challenges. Furthermore, Othman et al. (2023) identified various occupational stressors as major contributors to mental health issues among seafarers. These stressors include long working hours, isolation, and exposure to hazardous environments, which exacerbate psychological distress.

The impact of job insecurity and occupational stress on mental health is also significant. Yeoh (2023) reported that these factors negatively affect the mental well-being of maritime personnel, with many experiencing heightened anxiety and depression due to uncertain job conditions. Collectively, these findings highlight the urgent need for targeted mental health interventions and supportive policies to address the unique challenges faced by maritime personnel in Malaysia.

Table 1: Prevalence of mental health issues among maritime personnel in Malaysia based on various studies.

Study	Sample Size	Prevalence of Anxiety	Prevalence of Depression	Prevalence of Stress	Key Findings
Chan et al. (2021)	11,356	61%	39%	28%	High levels of anxiety, depression, and stress among emergency responders, including maritime personnel.
Samsudin et al. (2021)	N/A	30-61%	15-39%	13-28%	Firefighters, including maritime rescue personnel, exhibit significant mental health issues.
Razak (2019)	N/A	High	High	High	Significant job-related stress leading to burnout, anxiety, and depression among maritime personnel.
Othman et al. (2023)	N/A	High	High	High	Occupational stressors identified as major contributors to mental health issues among seafarers.
Yeoh et al. (2023)	N/A	High	High	High	Job insecurity and occupational stress significantly impact mental health among maritime personnel.

5.0 DISCUSSION

5.1 Interventions for Improving Mental Health

Interventions aimed at improving mental health among maritime personnel in Malaysia need to be multifaceted. Organizational support is crucial. Chan et al. (2021) emphasized the importance of awareness and usage of mental health resources in reducing psychological distress among employees. Employers should provide access to mental health services and promote a supportive work environment.

Psychological interventions, such as mindfulness and self-compassion training, have shown promise in reducing stress and enhancing well-being. Razak (2019) outlined the benefits of mindfulness training in the workplace, noting its effectiveness in reducing work stress and improving overall mental health. Similarly, (Berry et al., 2020) found that self-compassion is a strong predictor of mental health among young Malaysians.

Policy interventions are also necessary to address systemic issues. Azmi et al. (2021) highlighted the need for comprehensive legal frameworks and effective policies to support mental health at the workplace. Comparing policies in Malaysia with those in the UK, the study suggested that Malaysia has much to learn from more developed legal frameworks to support employee mental health.

Community and social support are also vital. Kok & Low (2019) emphasized the role of family and social support in mitigating mental health issues among Malaysian youth. Interventions that enhance social connectedness and provide support networks can significantly improve the psychological well-being of maritime personnel.

5.2 Policy Implications

Effective policies are essential to promote mental health and well-being among maritime personnel. The Occupational Safety and Health Act (OSHA) 1994 in Malaysia requires revisions to include provisions for mental health support. Azmi et al. (2021) recommended that Malaysia adopt comprehensive legal frameworks similar to those in the UK to better support mental health at the workplace.

The implementation of mental health off days is another policy initiative that could benefit maritime personnel. Yeoh (2023) highlighted the potential positive impact of mental health off days on employee well-being and job satisfaction. Employers should be encouraged to adopt such initiatives to support their employees' mental health.

Improving access to mental health services is critical. Berry et al. (2020) noted that the stigma associated with mental health issues and the lack of resources are significant barriers to help-seeking in Malaysia. Policies that promote mental health awareness and increase the availability of mental health services can help address these barriers.

Finally, policies should focus on improving working and living conditions for maritime personnel. Mat Zain & Lee (2022)suggested that improving onboard living conditions and providing better support for aquaculture workers can enhance their quality of life and mental well-being. Similar improvements can be made for maritime personnel to ensure their mental health is adequately supported.

6.0 CONCLUSION

The mental health and psychological well-being of maritime personnel in Malaysia is a critical area that requires urgent attention. This review has synthesized findings from multiple studies, highlighting a significant prevalence of mental health issues such as anxiety, depression, and stress among this population. Factors contributing to these issues include occupational stressors, psychosocial barriers, economic challenges, and poor living conditions. The high levels of psychological distress reported underscore the need for targeted interventions and supportive policies. The insights gained from this review can serve as a foundation for developing comprehensive mental health strategies tailored to the unique needs of maritime personnel.

Addressing the mental health needs of maritime personnel involves a multifaceted approach, integrating organizational support, psychological interventions, policy reforms, and community support. Organizational initiatives, such as providing access to mental health resources and promoting a supportive work environment, are crucial. Additionally, psychological interventions like mindfulness and self-compassion training have proven effective. Policy reforms, including revisions to the Occupational Safety and Health Act (OSHA) and the implementation of mental health off days, are necessary to create a supportive legal framework. Community and social support systems also play a vital role in enhancing the psychological well-being of maritime personnel. Future research should continue to explore these areas, providing more robust evidence to inform policy and practice.

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Energy Advancements and Strategies in Energy Management Systems for Hybrid Marine Power Solutions

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Abstract - The increasing demand for sustainable energy solutions in maritime transportation has driven the development of hybrid power systems for ships. This review explores the advancements in energy management systems (EMS) designed to optimize hybrid power systems in marine vessels. Emphasis is placed on integration strategies, control methodologies, and the performance metrics of these systems. Key findings highlight the potential of EMS to enhance fuel efficiency, reduce emissions, and improve operational reliability.

Keywords: Emission Reduction, Energy Management System, Hybrid Power System, Ships, Sustainable Maritime Transportation.

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1.0 INTRODUCTION

The maritime industry is pivotal to global trade but is also a significant contributor to greenhouse gas emissions. Traditional diesel-powered ships are increasingly being supplemented or replaced by hybrid power systems, which combine conventional engines with renewable energy sources and energy storage systems (Othman et al., 2018). The integration of these diverse power sources necessitates sophisticated EMS to ensure optimal performance and efficiency (Tang et al., 2019). Hybrid power systems for ships typically include components such as diesel engines, batteries, fuel cells, and solar panels. These components need to be managed in a way that balances power generation and consumption while minimizing fuel use and emissions (Hou et al., 2019). The primary challenge lies in developing EMS that can handle the dynamic nature of maritime operations and the varying availability of renewable energy sources (Xie et al., 2024). Recent research has focused on advanced control algorithms, predictive maintenance, and real-time optimization techniques to enhance the functionality of EMS in hybrid ships (Li et al., 2024). These advancements are crucial for achieving the International Maritime Organization's (IMO) targets for emission reduction and energy efficiency (Ammar, 2018).

This review aims to provide a comprehensive overview of the current state of EMS for hybrid power systems in ships, highlighting key technologies, methodologies, and performance outcomes. By synthesizing recent research findings, this paper seeks to identify future research directions and practical applications (Ebrahimi & Eren, 2022).

2.0 ENERGY MANAGEMENT SYSTEM TECHNOLOGIES

Energy management systems for hybrid ships leverage various technologies to optimize power distribution and consumption. These technologies can be broadly categorized into control strategies, power electronics, and communication systems (Yuan et al., 2018).

2.1 Control Strategies

Control strategies are critical for managing the interplay between different power sources and loads in hybrid systems. Model predictive control (MPC) has emerged as a promising approach due to its ability to handle multi-objective optimization problems (Jayachandran & Ravi, 2019). MPC uses real-time data to predict future states and make informed decisions about power distribution (Ammar, 2018). Another significant strategy is rule-based control, which relies on predefined rules to govern system behavior under various operating conditions. This approach is relatively simple to implement and has been effective in many practical applications (Moretti et al., 2021). However, it may not always achieve optimal performance, especially in complex and dynamic environments (W. Chen et al., 2023). Adaptive control systems are another area of interest, particularly for handling the variability in renewable energy sources. These systems adjust control parameters in real-time to optimize performance under changing conditions (Mokhtar et al., 2022).

2.2 Power Electronics

Power electronics play a crucial role in EMS by facilitating the conversion and control of electrical energy. Key components include inverters, converters, and battery management systems (BMS) (Mahfuz-Ur-Rahman et al., 2021). These components ensure that power from different sources is compatible with the ship's electrical grid and can be efficiently distributed (Paduraru et al., 2023). Recent advancements in wide-bandgap semiconductors, such as silicon carbide (SiC) and gallium nitride (GaN), have significantly improved the efficiency and reliability of power electronics in hybrid ships (Department of Energy, 2015). These materials offer superior thermal performance and higher switching frequencies, which are essential for maritime applications. Emerging technologies like solid-state transformers and advanced magnetic materials are also being explored to further enhance the performance of power electronic systems (Rahman et al., 2020).

2.3 Communication Systems

Effective communication systems are vital for coordinating the various elements of an EMS. These systems enable real-time data exchange between sensors, controllers, and actuators, ensuring seamless operation (Naji et al., 2020).The integration of Internet of Things (IoT) technologies has further enhanced the capabilities of EMS by providing detailed insights into system performance and facilitating predictive maintenance (Alves et al., 2020). The use of machine learning algorithms to analyze data from communication systems has shown promise in improving the accuracy and efficiency of EMS. These algorithms can identify patterns and anomalies, allowing for proactive management of power systems (Li et al., 2024). 5G technology is also being investigated for its potential to enhance the speed and reliability of communication systems in hybrid ships (Ait Allal et al., 2020). Figure 1 shows the overview for energy management systems.

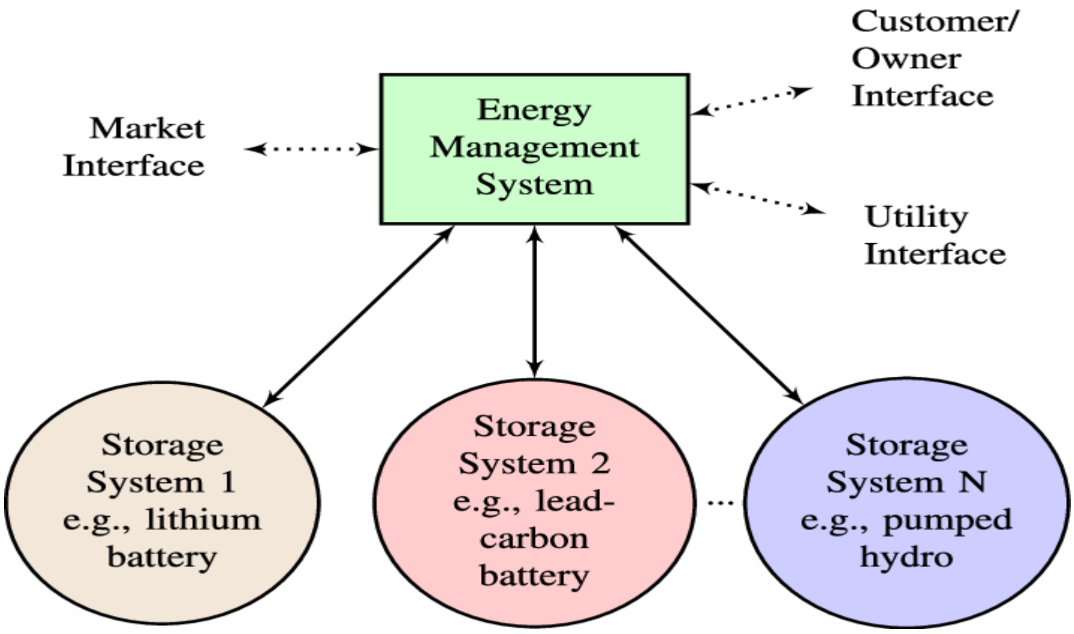

Fig. 1. Overview of Energy Management System Components (Byrne et al., 2017)

3.0 INTEGRATION STRATEGIES

Integrating various power sources and storage systems into a cohesive hybrid power system requires meticulous planning and execution. Effective integration strategies ensure that all components work harmoniously to achieve desired performance metrics (Ebrahimi & Eren, 2022).

3.1 System Architecture

The architecture of a hybrid power system significantly impacts its performance and reliability. Common architectures include series, parallel, and series-parallel configurations (Papadopoulos et al., 2022).Each configuration has its advantages and challenges, depending on the specific requirements of the ship and its operational profile (German-Galkin & Tarnapowicz, 2023). Series configurations are typically used when the primary goal is to minimize emissions, as they allow for efficient use of renewable energy sources (Al-Rawashdeh et al., 2023). Parallel configurations, on the other hand, are preferred for applications where reliability and redundancy are critical (Sadeghi et al., 2021). Series-parallel configurations offer a balance between these two approaches, providing flexibility in power management (Liu & Ruan, 2020).

3.2 Load Management

Load management is essential for optimizing the performance of hybrid power systems. Techniques such as demand-side management (DSM) and load forecasting are used to balance power generation and consumption (Amir et al., 2022). DSM involves adjusting the operation of non-critical loads based on the availability of power, while load forecasting uses historical data and predictive models to anticipate future power needs (Scarabaggio et al., 2022). Effective load management can significantly reduce fuel consumption and emissions by ensuring that renewable energy sources are used to their full potential (Bizon et al., 2015). It also enhances the reliability of the power system by preventing overloads and ensuring a stable supply of electricity (Hou et al., 2019).

Table 1. Comparison of Hybrid Power System Configurations (Geertsma et al., 2017)

Configuration	Advantages	Challenges
Series	High efficiency, low emissions	Complexity in control and integration
Parallel	High reliability, redundancy	Increased fuel consumption
Series-Parallel	Balanced performance, flexibility	Moderate complexity and control requirements

Table 1 shows a comparison of hybrid power system configurations. For situation of hybrid power system, for example the Solar-Wind Hybrid System combines solar and wind energy, leveraging their complementary nature to ensure a more consistent power supply. This setup requires significant space for both solar panels and wind turbines and involves high initial setup costs. It is ideal for areas that have both ample sunlight and wind resources (Abo-Alela, 2018). The Solar-Diesel Hybrid System integrates solar panels with diesel generators, providing reliable backup power and reducing fuel consumption and operational costs. However, diesel generators cause pollution and require regular maintenance, and fuel costs can be high. This configuration is best suited for remote locations with unreliable grid power where solar alone isn't sufficient (Esobinenwu, 2023).The Wind-Diesel Hybrid System uses wind turbines to reduce diesel fuel consumption and associated costs, offering a reliable power supply. The main challenges include the intermittency of wind resources and the pollution from diesel generators.

3.3 Control Coordination

Coordinating control actions across different components of a hybrid power system is crucial for maintaining optimal performance. Hierarchical control architectures, which include primary, secondary, and tertiary control levels, are commonly used to manage this complexity (Alam et al., 2023). Primary control handles real-time adjustments, secondary control focuses on maintaining system stability, and tertiary control optimizes long-term performance (Sedhom et al., 2020). Advanced control algorithms, such as decentralized and distributed control, have been developed to enhance the coordination of hybrid power systems. These algorithms enable individual components to operate semi-independently while still achieving overall system objectives (Bandla & Padhy, 2020). Figure 2 shows the hierarchical control architecture for hybrid power systems. Hierarchical control architecture in hybrid power systems ensures stability, efficiency, and reliability by dividing control into different levels. Primary control manages real-time voltage and frequency regulation with components like inverters and converters, responding within milliseconds to seconds. Secondary control adjusts primary control set points to correct frequency and voltage deviations from load changes, with response times of seconds to minutes. Tertiary control optimizes overall system operation using energy management systems, managing power flows and scheduling generators, responding within minutes to hours. Quaternary control focuses on long-term strategic planning, regulatory compliance, and infrastructure development, with response times of months to years. This architecture offers enhanced stability, scalability, efficiency, and resilience. It is crucial for applications like microgrids, smart grids, and remote power systems, ensuring smooth, efficient, and reliable operations.

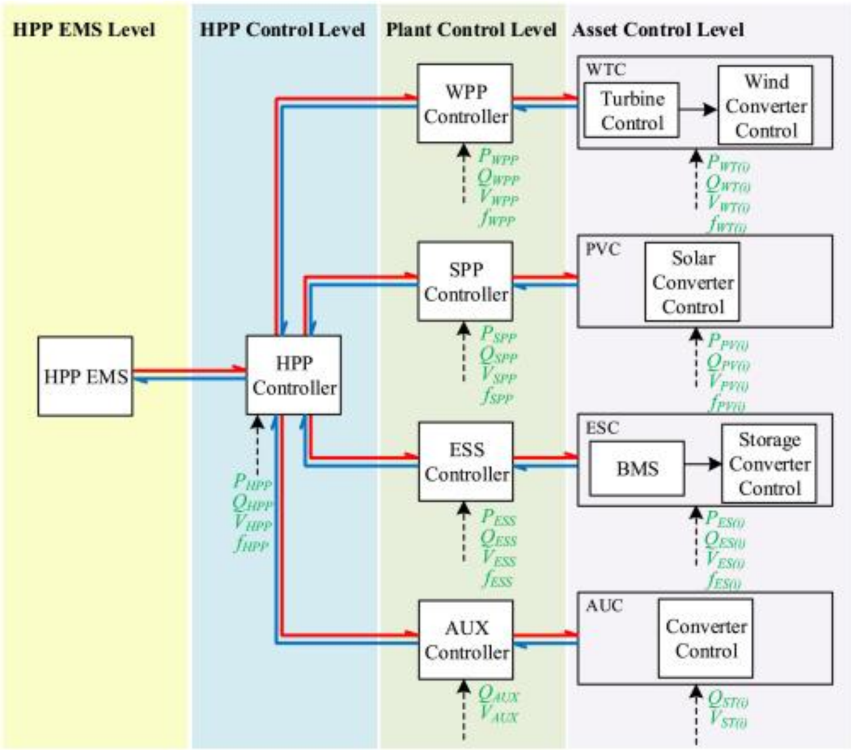

Fig. 2. Hierarchical Control Architecture for Hybrid Power Systems (Long et al., 2022)

4. PERFORMANCE METRICS

Evaluating the performance of EMS for hybrid power systems involves assessing various metrics, including fuel efficiency, emissions reduction, and system reliability (Ammar, 2018).

4.1 Fuel Efficiency

One of the primary benefits of hybrid power systems is improved fuel efficiency. By optimizing the use of renewable energy sources and energy storage systems, EMS can significantly reduce the amount of fuel consumed by ships (X. Chen & Guo, 2022) This not only lowers operational costs but also contributes to environmental sustainability (Tang et al., 2019).

4.2 Emissions Reduction

Reducing emissions is a key objective for the maritime industry, and hybrid power systems play a crucial role in achieving this goal. EMS enables ships to minimize their reliance on fossil fuels by integrating renewable energy sources and improving energy efficiency (Roslan et al., 2022). This results in lower emissions of greenhouse gases and other pollutants (Sletten & Zadeh, 2022).

4.3 System Reliability

Reliability is a critical factor for any maritime power system, given the harsh operating conditions and the need for continuous operation. Hybrid power systems enhance reliability by providing multiple power sources and ensuring redundancy (Daya & Lazakis, 2023). EMS plays a vital role in maintaining this reliability by monitoring system performance and making real-time adjustments as needed (Shafique et al., 2021).

Table 2 Performance Metrics of Hybrid Power Systems(Ammar, 2018)

Metric	Description	Significance
Fuel Efficiency	Measure of fuel consumption per unit of energy	Reduces operational costs and emissions
Emissions Reduction	Reduction in greenhouse gases and pollutants	Enhances environmental sustainability
System Reliability	Ability to maintain continuous operation	Ensures safe and reliable maritime transport

Table 2 is performance metrics of hybrid power systems. Fuel Efficiency measures fuel consumption per unit of energy produced. It reduces operational costs and emissions, making maritime operations more economical and environmentally friendly. Emissions Reduction involves decreasing greenhouse gases and pollutants. This enhances environmental sustainability and ensures compliance with international maritime regulations. System Reliability is the ability to maintain continuous operation. It ensures safe and reliable maritime transport by minimizing the risk of power outages and operational disruptions. These metrics help optimize hybrid power systems for better efficiency, sustainability, and reliability in maritime operations.

4.4 Economic Viability

The economic viability of hybrid power systems depends on factors such as initial investment, operational costs, and potential savings from reduced fuel consumption and maintenance (Iqbar et al., 2022).While the initial cost of hybrid systems can be high, the long-term benefits often outweigh these costs, making them a financially attractive option for ship operators (Cha et al., 2023). Figure 3 shows economic analysis of hybrid power systems. The hybrid system economic evaluation starts by defining objectives, such as cost reduction or increased reliability. Next, the system design and configuration are determined, identifying components like solar panels and batteries, and their capacities. Data on resource availability and load demand is collected. Cost analysis follows, calculating initial investment, operation, maintenance, and replacement costs. Economic parameters like discount rate and project lifespan are set. Energy production is simulated to estimate performance under various conditions.

Financial analysis includes calculating Net Present Value (NPV), Levelized Cost of Energy (LCOE), payback period, and Internal Rate of Return (IRR). Sensitivity analysis assesses the impact of changing parameters, while risk assessment identifies potential risks. Environmental impact is evaluated for benefits like carbon savings. Decision-making compares different configurations based on economic and environmental analyses. Implementation planning and monitoring are then established to track performance and adjust. This process ensures a comprehensive evaluation of the hybrid system's economic viability.

CONCLUSION

Energy management systems are critical for the effective operation of hybrid power systems in ships. The integration of advanced control strategies, power electronics, and communication systems has significantly enhanced the performance and reliability of these systems. Hybrid power systems offer substantial benefits in terms of fuel efficiency, emissions reduction, and economic viability. However, further research is needed to address challenges such as system complexity and integration. Future work should focus on developing more sophisticated control algorithms, improving the efficiency of power electronics, and enhancing communication systems. Additionally, real-world trials and pilot projects are essential for validating theoretical models and demonstrating the practical benefits of hybrid power systems in maritime applications.

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Advancements in Wheel Over Point Calculations: Enhancing Navigational Safety and Efficiency

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Abstract - The manoeuvrability of single-propeller vessels is essential in maritime activities, especially in narrow waterways. The "wheel over point," a crucial characteristic for manoeuvring, guarantees secure and effective navigation. This study examines the theoretical and practical ramifications of the subject, with a focus on contemporary technological breakthroughs. Hydrodynamic models and computational fluid dynamics (CFD) simulations have enhanced the accuracy of wheel-over-point estimates by including elements such as water resistance and external disturbances. The efficacy of real-time data systems in improving vessel manoeuvring is demonstrated by their practical use in crowded ports. Technological progress, such as the development of AI and machine learning, improves the capacity to make predictions and helps to increase fuel economy and promote sustainability. Simulation tools, virtual reality (VR), and augmented reality (AR) offer extensive training platforms for those working in the marine industry. Future research should prioritise the development of adaptive navigation systems and the integration of real-time data to enhance navigational safety and operational efficiency.

Keywords: Wheel over point, single propeller vessel, maneuverability, computational fluid dynamics, navigational safety

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1.0 INTRODUCTION

The navigation of single propeller vessels presents unique challenges, particularly concerning maneuverability in restricted water. The "wheel over point" refers to the precise location at which a vessel initiates a turn to follow a planned trajectory accurately (Kamis, Ahmad Fuad, Ashaari, & Mohd Noor, 2021). This review aims to dissect the intricacies of the wheel over point, emphasizing its importance in maritime navigation and safety.

Recent studies have highlighted the critical nature of maneuvering parameters in preventing maritime accidents (Yaacob et al., 2014). Effective maneuvering strategies are essential to avoid collisions, particularly in confined and heavily trafficked waterways (Chauvin et al., 2013; Omelchenko & Petrichenko, 2020). Accurate determination of the wheel over point can significantly reduce the risk of groundings and collisions, contributing to safer maritime operations (IMO ISM, 2018; Kamis, Ahmad Fuad, Ashaari, & Mohd Noor, 2021).

The advent of advanced simulation tools and real-time monitoring technologies has further enhanced the precision of these maneuvers. For instance, modern ship simulators allow for testing of theoretical models and provide real-time feedback, improving the accuracy of wheel over point determinations (Kuznetsov et al., 2021; Zhu et al., 2014).

The wheel over point is influenced by various factors, including vessel speed, turning radius, and hydrodynamic forces. Understanding these factors is essential for navigators and maritime engineers to optimize vessel performance and ensure safe passage through narrow channels and busy ports (Kamis et al., 2022; Sahin, 2016). This review synthesizes recent research findings and integrates them with established maritime practices. By exploring both theoretical frameworks and practical applications, the article provides a comprehensive overview of the wheel over point's role in single propeller vessel navigation (Kamis, Ahmad Fuad, Ashaari, & Mohd Noor, 2021).

Table 1: Factors Influencing Wheel Over Point Determination

Factor	**Description**	**Source**
Vessel Speed	Speed at which the vessel is traveling	(Kamis, Ahmad Fuad, Ashaari, & Mohd Noor, 2021; Lee, 2012)
Turning Radius	Radius of the vessel's turn	(Kamis, Ahmad Fuad, Ashaari, & Mohd Noor, 2021; Muscari et al., 2017)
Hydrodynamic Forces	Forces acting on the vessel from water resistance and propulsion	(Faltinsen, 2006)
External Disturbances	Impact of wind, currents, and waves	(Lee et al., 2015)

2.0 Theoretical Framework and Hydrodynamic Considerations

The theoretical foundation of the wheel over point is grounded in the principles of ship hydrodynamics and control theory. The interaction between a vessel's hull, propeller, and rudder plays a pivotal role in determining its maneuvering characteristics (Muscari et al., 2017) as seen in Figure 1.

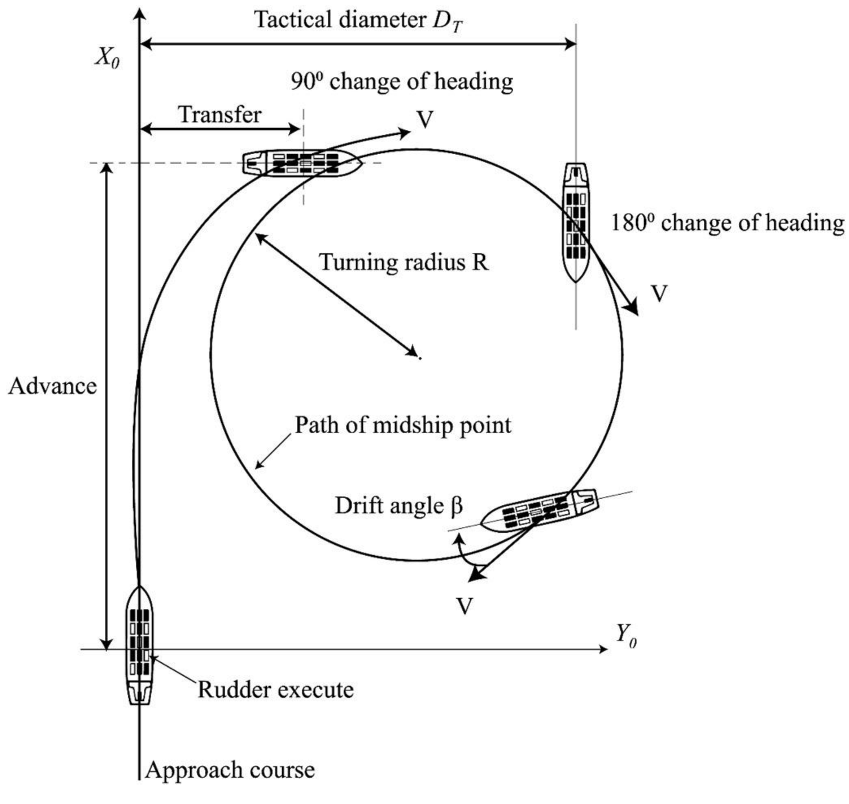

Figure 1: Maneuvering characteristic of a ship (ITTC, 2002)

Hydrodynamic models have been extensively developed to predict the behavior of single propeller vessels under various conditions. These models consider various factors such as the effects of water resistance, propulsion forces, and external disturbances like wind and current. Recent advancements include detailed computational fluid dynamics (CFD) simulations that have significantly improved the accuracy of these predictions (Razaghian et al., 2021; Roshan et al., 2020). These models consider the effects of water resistance, propulsion forces, and external disturbances such as wind and current (Y. Liu et al., 2021). Advanced computational fluid dynamics (CFD) simulations have enabled more accurate predictions of these interactions, aiding in the precise calculation of wheel over points (Villa et al., 2020).

Empirical studies have provided valuable insights into the practical aspects of maneuvering. Field experiments using scale models and full-scale trials have validated theoretical predictions and highlighted the importance of contextual factors such as water depth and vessel loading (Wang et al., 2020). These findings underscore the complexity of determining the wheel over point and the need for comprehensive modeling approaches (Miyazaki et al., 2001).

Moreover, recent advancements in sensor technologies and real-time data analytics have revolutionized maritime navigation. Integrated navigation systems that utilize GPS, AIS, and sonar data provide continuous monitoring and adjustment of wheel over points, enhancing navigational accuracy and safety (J. Liu & Hekkenberg, 2017).

2.1 Technological Advancements and Simulation Tools

Technological advancements have significantly impacted the study and application of wheel over points in single propeller vessels. Simulation tools, in particular, have emerged as indispensable resources for maritime training and operational planning. Modern bridge simulators offer highly realistic environments where navigators can practice maneuvers and understand the dynamics of wheel over points without the risks associated with real-world trials (Komasawa et al., 2019). These simulators incorporate detailed hydrodynamic models and real-time data inputs, providing a comprehensive training platform for maritime professionals (Nicolescu et al., 2007).

Furthermore, the integration of artificial intelligence (AI) and machine learning algorithms into navigation systems has enhanced the predictive capabilities of wheel over point calculations. AI-driven models can analyze vast amounts of historical data to identify patterns and optimize maneuvering strategies (Gunathilake et al., 2014). This technological synergy not only improves safety but also contributes to fuel efficiency and environmental sustainability (Vardhan et al., 2021).

The use of virtual reality (VR) and augmented reality (AR) in maritime training represents another significant advancement. These immersive technologies provide interactive experiences that enhance the understanding of complex navigational concepts, including the wheel over point. By combining theoretical knowledge with practical application, VR and AR tools bridge the gap between classroom learning and real-world operations (Shen et al., 2019).

2.2 Practical Applications and Case Studies

Practical applications of wheel over point concepts are critical for ensuring the safety and efficiency of maritime operations. Numerous case studies have documented the successful implementation of these principles in various maritime contexts, offering valuable lessons and best practices (Kamis & Ahmad Fuad, 2021).

One notable example is the application of wheel over point strategies in busy port areas. Ports such as Rotterdam and Singapore have implemented advanced navigation systems that utilize real-time data to optimize vessel maneuvering and reduce the risk of accidents. These systems continuously monitor vessel positions and environmental conditions, providing navigators with precise instructions on when to initiate turns (Filipiak et al., 2020).

Research has also demonstrated the effectiveness of wheel over point optimization in reducing fuel consumption and emissions. By fine-tuning maneuvering strategies, vessels can maintain optimal speeds and trajectories, leading to significant environmental benefits. This approach aligns with global efforts to enhance the sustainability of maritime operations (De et al., 2019).

Moreover, the adoption of wheel over point principles in pilot training programs has yielded positive results. Pilots trained with a thorough understanding of these concepts are better equipped to handle challenging navigational scenarios, such as navigating through narrow channels and under adverse weather conditions. This training has been instrumental in improving overall navigational safety and efficiency (Mallam et al., 2019).

4.0 Challenges and Future Directions

Despite the advancements in understanding and applying wheel over points, several challenges remain. The complexity of accurately modeling hydrodynamic interactions and external forces poses ongoing difficulties for researchers and practitioners. Modelling hydrodynamic interactions requires intricate calculations to forecast the stresses and torques exerted on boats, which are influenced by several environmental parameters, such as ship draft and water depth (Kamis, Ahmad Fuad, Ashaari, Noor, et al., 2021; Zhang et al., 2021) as seen in Figure 2.

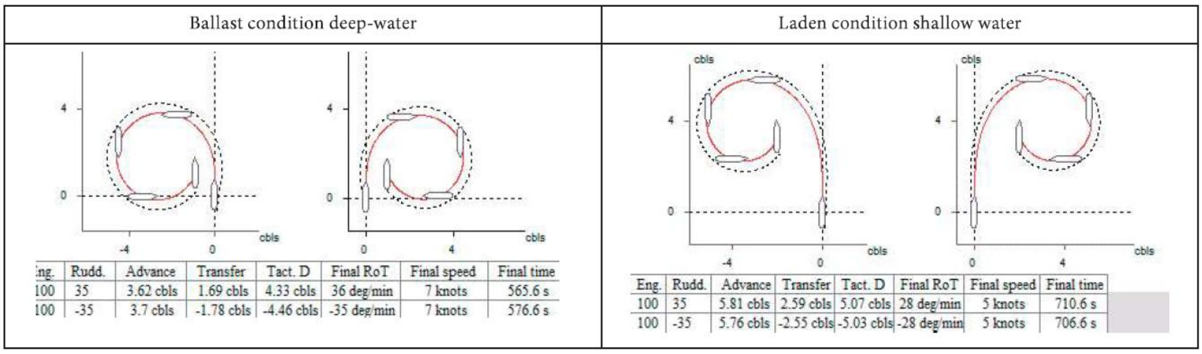

Figure 2: The variation in a ship's draft impacts the turning radius of the vessel (Kamis, Ahmad Fuad, Ashaari, Noor, et al., 2021).

One significant challenge is the variability of environmental conditions. Factors such as tidal currents, wind, and wave patterns can significantly impact the accuracy of wheel over point calculations. Developing robust models that can adapt to these changing conditions is essential for enhancing the reliability of navigational systems (Ley & Bruus, 2016).

Another challenge is the integration of emerging technologies into existing maritime infrastructures. While AI, VR, and AR offer substantial benefits, their implementation requires significant investments in training and equipment. Ensuring that these technologies are accessible and user-friendly is crucial for their widespread adoption (Vacondio et al., 2021).

Future research should focus on developing adaptive navigation systems that can respond dynamically to real-time data. The integration of IoT devices and advanced sensors can provide continuous monitoring and feedback, enabling vessels to adjust their maneuvering strategies on the fly (Zhang et al., 2021). Additionally, collaborative efforts between academia, industry, and regulatory bodies are essential for establishing standardized practices and guidelines for wheel over point determination (Vacondio et al., 2021).

5.0 Conclusion

The concept of the wheel over point is fundamental to the safe and efficient navigation of single propeller vessels. Through a combination of theoretical frameworks, technological advancements, and practical applications, significant progress has been made in optimizing these maneuvers. However, ongoing research and innovation are necessary to address the remaining challenges and further enhance navigational safety and operational efficiency.

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Monitoring System for Hydrophore Tank Onboard Using Micro-controller

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Abstract - In the maritime industry, the seamless operation of onboard systems is paramount for ensuring both safety and efficiency. Central to this operation is the hydrophore system, which maintains essential water pressure throughout the vessel. The reliable performance of hydrophore units hinges upon the careful management of water pressure, water level, and pH balance. However, ensuring optimal performance necessitates a robust monitoring system capable of integrating these parameters seamlessly. This paper proposes an integrated monitoring system tailored specifically for hydrophore tanks onboard ships. By leveraging real-time monitoring and automation alerts, this system not only enhances operational safety but also streamlines maintenance protocols, thereby ensuring uninterrupted vessel functionality. Through the implementation of such a monitoring system, maritime operators can effectively mitigate risks associated with hydrophore malfunction, ultimately safeguarding both crew and cargo while optimizing operational efficiency at sea.

Keywords: Microcontroller, pH level, Water level, Water pressure

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1.0 INTRODUCTION

The reliable operation of hydrophore tanks onboard ships is crucial for ensuring a continuous and adequate water supply necessary for various shipboard operations. However, conventional monitoring methods often fall short in providing comprehensive oversight, leading to unforeseen maintenance issues, operational inefficiencies, and potential safety hazards. In this context, local monitoring practices typically involve manual checks of water levels, with limited attention to water quality and pump performance. Consequently, critical factors such as pump runtime, water pH, and potential air lock occurrences remain unrecorded, posing risks to both equipment longevity and crew well-being.

The absence of systematic data recording exacerbates these challenges, leaving ship operators with no insights into pump runtime, frequency of start-stop cycles, or the overall condition of the hydrophore system. Without accurate records, identifying underlying issues such as dry running pumps or water contamination becomes a daunting task, often leading to unpredictable maintenance events and increased machinery wear.

Recognizing these limitations, there arises a compelling need for a proactive solution capable of real-time monitoring, automated alerts, and data-driven insights to mitigate risks and optimize hydrophore system performance. Thus, the concept of Smart hydrophore Monitoring (SHM) emerges as a promising approach to address these challenges.

By implementing SHM technology, ship operators can gain unprecedented visibility into key parameters such as water pH, pressure levels, and water quality in real-time. Moreover, the integration of data storage capabilities enables historical analysis, facilitating trend identification and proactive maintenance planning. This shift towards predictive maintenance not only minimizes downtime and repair costs but also prolongs the lifespan of critical machinery, ensuring operational continuity and safety at sea.

2.0 OBJECTIVE

The primary objective of this system is to enhance the efficiency and reliability of hydrophore tank systems onboard ships by integrating a robust monitoring mechanism. This system aims to reduce unnecessary repair costs through predictive maintenance while ensuring optimal performance of the hydrophore system. Additionally, it seeks to guarantee a consistent and uninterrupted water supply, which is crucial for various onboard operations. By automating monitoring processes, the system significantly reduces the workload on crew members, allowing them to focus on other critical tasks. Furthermore, it emphasizes maintaining high water quality standards to safeguard both human health and the longevity of onboard machinery.

3.0 PROCEDURE

An MCU will monitor changes in the variable resistor to determine the pH level. It is possible to alter the resistance while the simulation is running with a variable resistor. The ADC transforms the analog signals that the MCU receives into digital values. The ADC module is integrated within the microcontroller. An LCD is used to display the digital values. In order to enable serial or parallel data entry into the system, a shift and store bus register were implemented between the microcontroller and LCD. A pressure sensor is employed in pressure measurement to identify variations in the hydrophore tank pressure. The ADC is used by the MCU to transform the signals it receives into digital values. The ADC module is integrated within the microcontroller. LCD is used to display the pressure's digital value.

4.0 SYSTEM PROCESS

The flowchart in Fig.1, represents a systematic process for managing water levels using a motor control system. The process begins by collecting real-time data from water level sensors to monitor the current water level in the tank. This sensor data is then analyzed by a controller, which decides based on predefined water level conditions. If the water level is sufficient, the controller ensures the motor remains powered off to prevent unnecessary operation.

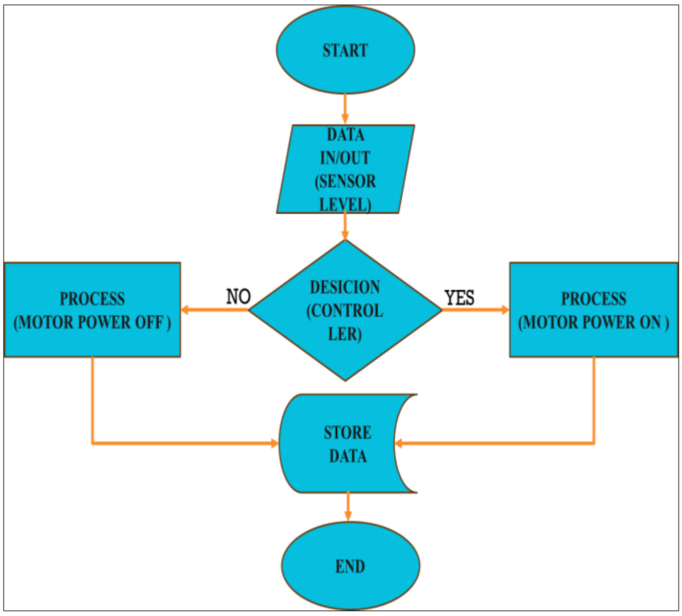

Fig. 1. The flowchart of the water level

However, if the water level falls below the required threshold, the controller activates the motor to refill the tank. Additionally, the system records the sensor data and corresponding motor activity to enable monitoring and analysis for future reference. This process ensures efficient water level management, conserves energy, and supports consistent water supply without manual intervention.

The Table 1 below outlines the system's response based on the inputs from three sensors monitoring water or pressure levels. Each sensor represents a specific level: Sensor 1 (High Level), Sensor 2 (Normal Level), and Sensor 3 (Low Level). The outputs include the Buzzer and Motor, which are triggered depending on the sensor readings.

Table 1. *Truth table for Water level*

Conditions	***Input***			***Output***	
	Sensor 1	***Sensor2***	***Sensor 3***	***Buzzer***	***motor***
A	0	0	0	1	0
B	0	1	0	0	0
C	1	0	0	1	0
D	0	0	1	1	1

Note: the outputs based on the readings from three sensors monitoring different water or pressure levels. Sensor 1 indicates a high level, Sensor 2 represents a normal level, and Sensor 3 signals a low level. These sensor inputs are used to trigger specific actions, such as activating or deactivating alarms (e.g., buzzer) or controlling the motor, ensuring efficient system management and prompt responses to varying conditions.

The flowchart in Fig. 2 below illustrates a process for monitoring and managing pH levels in a system using a sensor-based control mechanism. The process begins with system initialization, followed by data collection from a pH sensor that measures the real-time pH level of the water or fluid. The controller then evaluates the sensor data to determine whether the pH level is within the acceptable range.

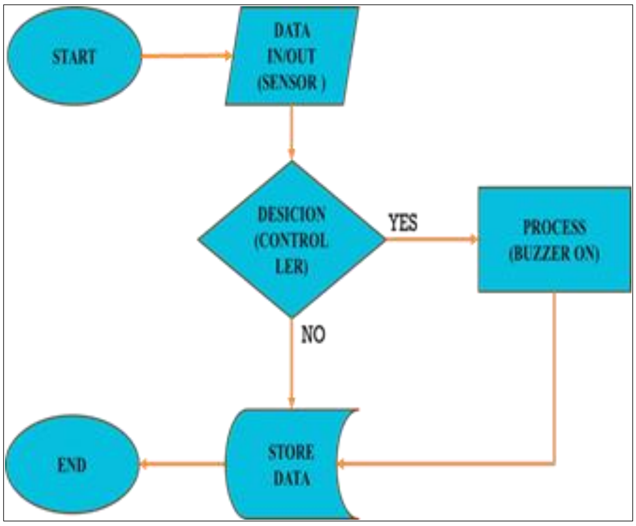

Fig. 2. The flowchart of the pH level

If the pH level is outside the desired range, the controller triggers a buzzer to alert the operator to take corrective action. If the pH level is within the acceptable range, no alert is activated, and the system continues normal operation. Regardless of the outcome, all pH level data is stored for monitoring, analysis, and future reference to facilitate trend identification and proactive maintenance. This process ensures that the pH level is consistently monitored, helping to maintain water quality and safety while enabling timely interventions when necessary. The table 2 shows the system will ensures timely alerts for pH deviations, allowing corrective actions to maintain water quality within safe operational limits.

Table 2. *Truth table for pH level*

Conditions	***Input***			***Output***	
	Sensor 1	***Sensor2***	***Sensor 3***	***Buzzer***	***motor***
A	0	0	0	1	0
B	0	1	0	0	0
C	1	0	0	1	0
D	0	0	1	1	0

Note: The truth table demonstrates the system's behavior based on inputs from three sensors monitoring pH levels. Each sensor corresponds to a specific range: Sensor 1 for high pH levels, Sensor 2 for normal pH levels, and Sensor 3 for low pH levels. The outputs are defined by the Buzzer, which signals an alert, and the Motor, which remains inactive in this pH monitoring system

The flowchart in Fig. 3, represents the process of monitoring and managing water pressure in a system using sensor-based technology. The process starts with the initialization of the system, followed by the collection of real-time pressure data from sensors. This data is analyzed by the controller to determine whether the pressure level is within the desired range. If the pressure exceeds or falls below the acceptable range, the controller activates a buzzer to alert the operator, signalling the need for corrective action.

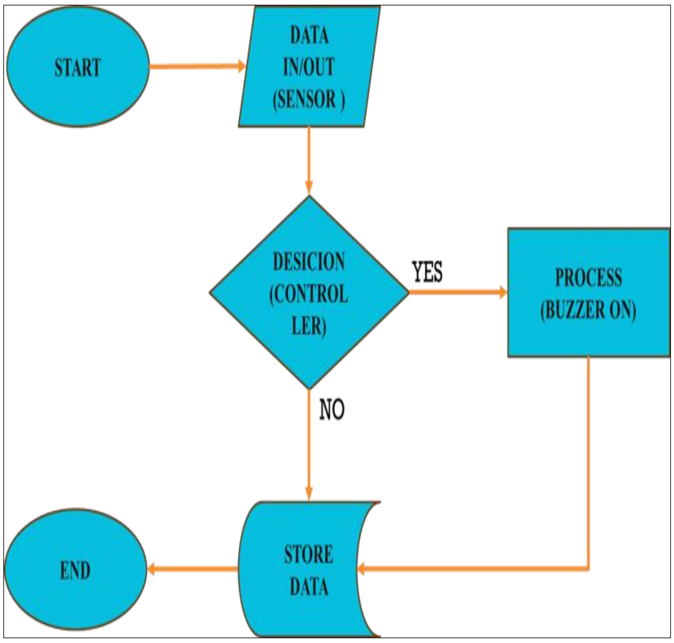

Fig. 3. The flowchart of the water pressure

If the pressure level is within the acceptable range, the system continues to operate without triggering any alerts. In both cases, the collected pressure data is stored for further monitoring, analysis, and trend evaluation. This ensures proactive maintenance and system efficiency. The process concludes once all necessary actions have been executed, preparing the system for continuous monitoring. This approach ensures optimal water pressure levels, enhances operational safety, and minimizes the risk of equipment failure. Table 3 ensures the system responds appropriately to maintain optimal pressure, providing timely alerts and corrective actions when necessary.

Table 3. *Truth table for pressure level*

Conditions	***Input***			***Output***	
	Sensor 1	***Sensor2***	***Sensor 3***	***Buzzer***	***motor***
A	0	0	0	1	0
B	0	1	0	0	0
C	1	0	0	1	0
D	0	0	1	1	1

Note: The table outlines the system's response based on pressure level inputs from three sensors, where Sensor 1 detects high pressure, Sensor 2 indicates normal pressure, and Sensor 3 detects low pressure. The outputs include a Buzzer, which triggers alerts, and a Motor, which activates only under specific conditions

Fig.5 below shows the comprehensive representation of a monitoring and control system designed to measure and manage pH levels, pressure levels, and water levels.

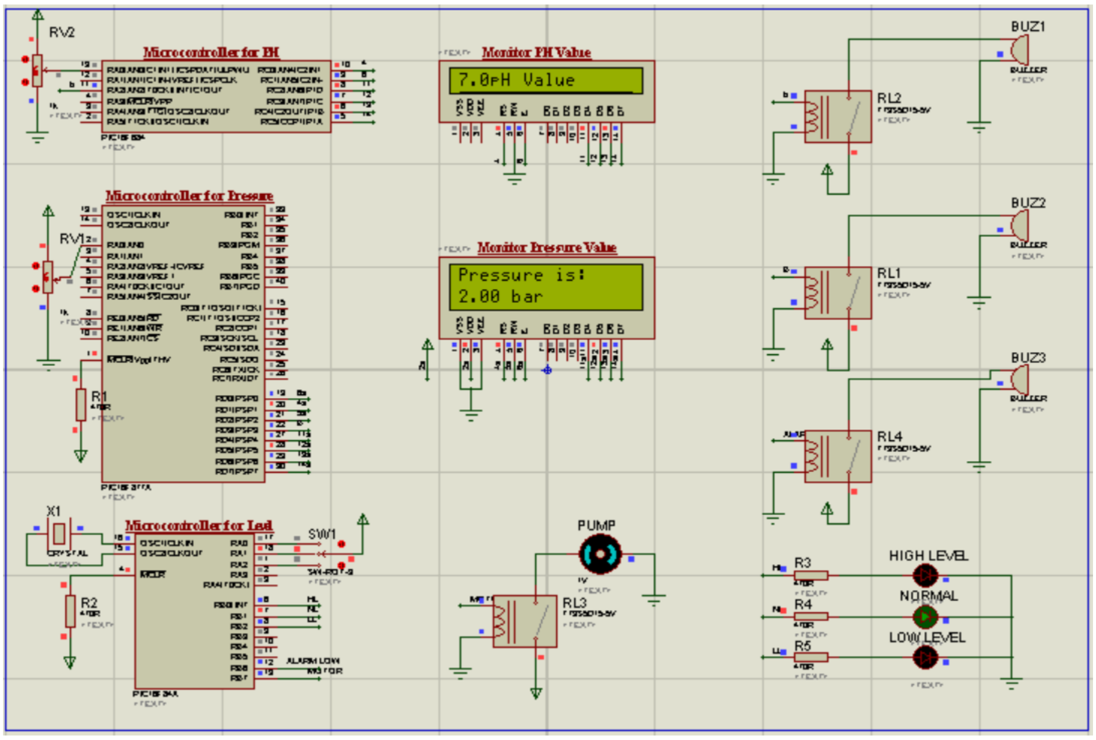

Fig. 5 The layout of circuit

This circuit provides a complete monitoring and control solution for managing pH levels, pressure levels, and water levels in a system. The integration of sensors, microcontrollers, LCDs, relays, and alarms ensures real-time monitoring, efficient control, and timely alerts to prevent failures or damages in the system.

5.0 DISCUSSION AND CONCLUSION

In summary, the monitoring system for hydrophore tanks onboard ships is a game-changer in water distribution system management. By providing real-time insights and enabling proactive maintenance, it enhances operational efficiency and reliability while contributing to sustainability efforts. Its potential applications extend beyond maritime industries, promising advancements in water management practices worldwide. This system represents a significant leap forward in ensuring safe, efficient, and sustainable water distribution systems across various applications and sectors.

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Fire Detection System – Auto Start Fire Pump when Manual Call Point Activated

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Abstract - All seaworthy vessels must comply with SOLAS Chapter II-2 under the International Code for Fire Safety System (FSS Code) and be equipped with a reliable Fire Extinguishing System. In the event of an emergency during a voyage, only the ship's crew is available to combat any uncontrollable fire, as assistance from the shore is not feasible when the vessel is far from land. The existing fire extinguishing system design is not equipped with an Auto-running of the Emergency Fire Pump or the Fire Pump in the event when a manual call point is activated. To solve this problem, the vessel's fire systems would need to have a design that incorporates the Fire Control Panel, Manual Call Points, Fire Pump and Emergency Fire Pump in an integrated parallel arrangement with the control of microcontroller. This arrangement allows the Fire Pump or Emergency Fire Pump to run automatically when a Manual Call Point is activated.

Keywords: Auto Start, Fire Detection System, Fire Pump, Integrated Parallel System, Manual Call Point (MCP)

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1.0 INTRODUCTION

All vessels must be equipped with a fixed fire extinguishing system that complies with applicable standards. The SOLAS Chapter II-2, under the FSS Code, outlines standards for vessel fire pump systems. According to these standards, the primary equipment includes the main fire pump and the emergency fire pump. However, current designs of fire extinguishing pump systems, as discussed in relevant journals, have a significant weakness: the main fire pump and emergency fire pump are not integrated with the fire detection panel.This paper proposes a solution to this issue by introducing a system where, upon activation of a manual call point (based on its location), either the main fire pump or the emergency fire pump will automatically start and pressurize the fire line. This integration aims to reduce the response time in the event of a fire (Samosir, 2021).

2.0 PROCEDURAL

The PIC16F84A Microcontroller will be connected to the existing Fire Alarm Control Panel, creating a link between the Manual Call Points to the Main Fire Pump & Emergency Fire Pump based on the location of the fire onboard the ship. Fig. 1 shows the Flow Chart of the Main Fire Pump or Emergency Fire Pump upon activation of the MCP. This is achieved using several existing and additional components, which include an LCD Screen, LED Warning Lights, and Buzzers to complete a circuit that achieves the intended function.

By including these components, the effectiveness of the Fire Detection System is believed to be enhanced to allow all crew to muster and prepare themselves for firefighting, while the fire pump is primmed and ready for immediate use as required, without worrying about the risk of obstructions or lack of manpower within the Roving Team to prepare the fire line for use. As an example, Fig. 3 shows an excerpt from the Seri Ayu Machinery Operating Manual which incorporates the Main Fire Pump and Emergency Fire Pump to the Fire Control Panel. the flowchart outlines a fire monitoring and response system that incorporates both manual and automated processes to detect and address fire incidents. The process begins by checking if the manual bypass is activated; if so, the system relies on manual controls, and the MCP (Manual Call Point) is checked for activation. If the MCP is triggered, fire panels in the affected location (engine room or outside) detect the fire, print a report, and activate fire alarms, lamps, and either the emergency or main fire pumps. If the MCP is not activated, the system remains in normal condition or identifies a system fault, recommending the replacement of the MCP. In case of manual bypass with activation, fire alarms and lamps are controlled manually, and pumps switch to manual mode. This structured approach ensures efficient detection, alerting, and mitigation of fire-related incidents while addressing potential system faults.

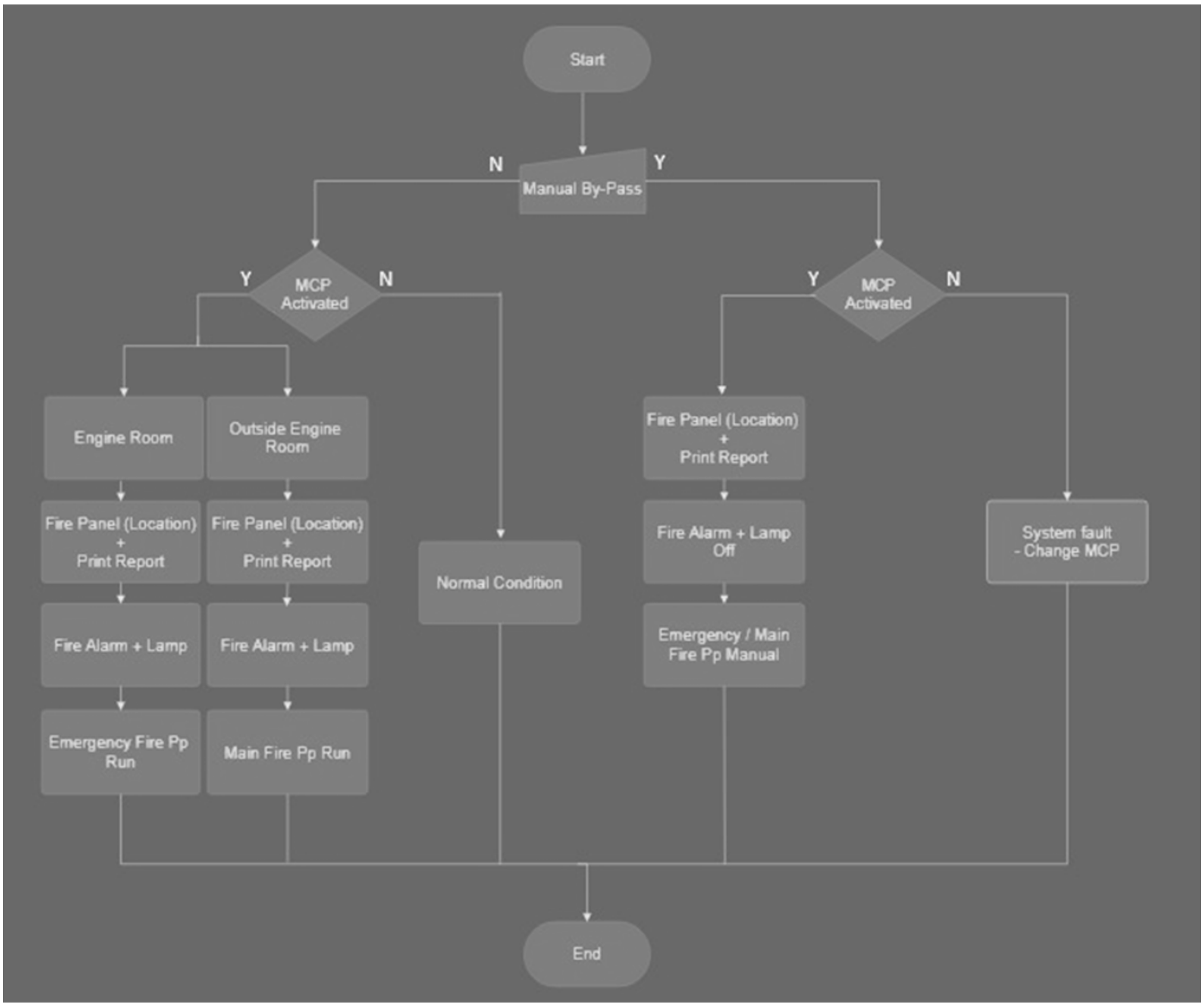

Fig. 1. Flow Chart of the Main Fire Pump

Table 1 below demonstrates the system's capability to respond appropriately to fire incidents at specific locations or simultaneously across multiple areas, ensuring comprehensive fire safety and alert mechanisms.

Table 1. Truth Table showing the operation of the system

Input		Output				
MCP Activation Point Deck	**MCO Activation Point ER**	**Emergency Fire Pump**	**Main Fire Pump**	**Siren + Light**	**AHU + Fire Doors**	**LCD Display**
0	0	0	0	0	0	0
1	0	0	1	1	1	1
0	1	1	0	1	1	1
1	1	1	1	1	1	1

The system's response to different input conditions is based on the activation of Manual Call Points (MCP) on the deck and in the engine room (ER). Depending on the input, the system activates the appropriate fire pumps (Emergency or Main), triggers alarms (Siren + Light), closes safety mechanisms (AHU + Fire Doors), and updates the status on the LCD display. The table ensures clarity in how the system responds to fire incidents in specific locations or simultaneously across multiple areas.

The Fig.2 below illustrates the fire detection and response system with integrated control for alarms and fire pumps. It uses multiple microcontrollers (PIC16F84A) to process input signals from various sensors and switches, including bypass and location selectors, which determine the activation points (engine room or outside). The Fire Detection Panel Display provides real-time status updates on the system's operation. Relays (RL1, RL2, RL3) control the activation of fire alarms, alarm column lamps, and fire pumps (Main and Emergency). The buzzer and lamp provide audible and visual alerts in case of fire detection. This system ensures efficient monitoring, alerting, and action for fire incidents in designated areas.

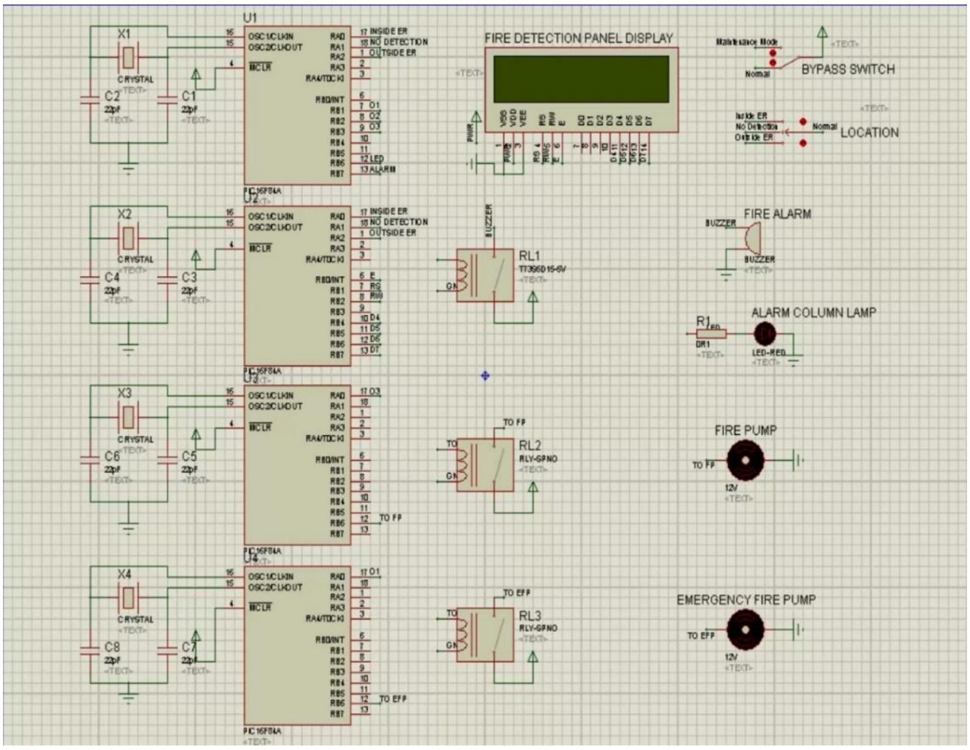

Fig 2. circuit of the Fire Detection System

The Fig.3 below depicts a centralized fire detection and alarm system integrated with multiple panels and devices for comprehensive monitoring and response. The BS-320M Central Unit connects to the ship's supply, providing power to various loops, detectors, and control panels (F.C.S. and C.C.S.). It interfaces with other systems via Modbus for serial communication. Detector loops (e.g., Loop 1 to Loop 9) monitor different zones for fire or smoke, while outputs trigger alarms, fans, or system responses such as stopping ventilation or activating fire alarms. The system ensures reliable communication, with CAT 5 cabling linking information panels and controlled delay mechanisms for emergency actions. This setup provides a robust safety system tailored for shipboard environments.

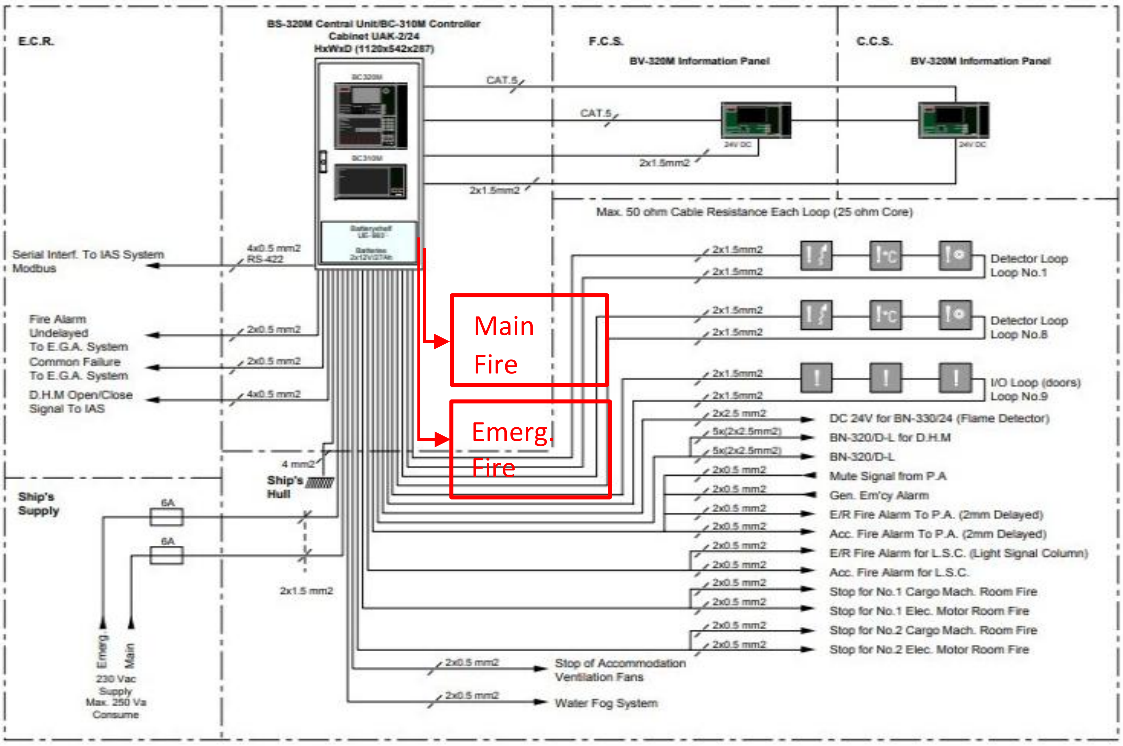

Fig. 3 Fire Alarm Panel of Seri Ayu

4.0 OUTPUT

Based on the output simulated, it was discovered that the design successfully performs the following actions to achieve the intended result to create a more fire detection system onboard ship. The design activates the fire pump or emergency fire pump upon activation of Manual Call Point (MCP) to avoid delays in the pressurization of the fire line for use, prevent loss of time during emergencies, prevents the possibilities of obstacles affecting the effectiveness of firefighting effectiveness, to provide a safer guideline for firefighting onboard ship and to highlight the importance of ensuring the fire line is ready for use at a moment's notice.

Marine fire pumps, as a primary source of fire extinguishing, provide the water to extinguish any fire in a ship. These pumps carry seawater or foam to put out the fire quickly before it gets out of hand. Initial findings show that there are no automatic controls for the primary fire system onboard vessels. Water would have to be directed to the fire manually in the event of an emergency, through fire hydrant and hoses, pressurized by fire pumps. (Company, 2020) For vessels with Fixed Fire Fighting Systems that operate on hyper mists of a Fresh Water extinguishing medium, this method only covers certain critical areas. It is an independent system but readily integrated with the Fire Detection Panel, unlike the Fire Pump system.

In the event of fire, current vessel fire detection panels include isolating ventilation at accommodation, galley equipment, fire alarm and accommodation fire door. With the incorporation of the system, the user-friendliness of the Fire Fighting System onboard vessels can be enhanced in line with the FSS Code.

Manual Call Points (MCPs) are crucial components of any building's fire detection system. MCPs serve several vital functions, including:

• Sounding the alarm to warn everyone inside about a potential fire hazard
• Promptly starting the evacuation process
• Triggering the alarm if the automated detection system is not working
• Alerting the fire alarm control panel to the location of the fire
• Informing the fire services about the fire, either manually or automatically
• Engaging the smoke management system

(Evacuator Site Alarms, 2021)

With the introduction of the system, the MCP then adopts an additional function of starting the Fire Pumps to further enhance the standards of safety on board ship.

From a regulatory standpoint, articles that mention firefighting standards insist that the primary purpose of establishing a separate Code (FSS Code) was to distinguish between carriage and other statutory requirements, which appropriately belong in the Convention and are intended for the Administration, and purely technical provisions. These technical details are better placed in the Code, allowing equipment manufacturers, system engineers, and others to apply them in a more user-friendly manner. (IMO, International Maritime Organization, 2021)

5.0 DISCUSSION AND CONCLUSION

With the implementation of the design to the Fixed Fire Fighting System, fire-fighting safety standards will be improved in ways that will greatly benefit the shipping industry. The design itself potentially creates a more reliable, and accurate, response time-to-action ability that will ensure the water pressures in the fire lines are ready for use when required. A vessel's existing Fire Detection Panel can be integrated with the Fire Pump and Emergency Fire Pump by activating the Manual Call Points (MCP). The system not only serves as a function to pressurize the fire line automatically, but also ensures no unforeseen circumstances occur in the absence of the Roving Team. It also allows the Main Fire Pump or Emergency Fire Pump to start automatically with the MCP activated in case a location becomes difficult to access during an emergency.

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Seri Ayu Machinery Operating Manual

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Water Detector for Main Air Compressor Sump Oil

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Abstract - Water contamination in the oil sump has always been a problem with air compressor machines used in marine shipping. It is often too late to detect it through a sight glass which leads to compressors being damaged, especially in Unmanned Machinery Spaces (UMS). The proposed solution is developing a sensor system like Main Engine Water Observation and Information System (WOIS) but using different types of sensors that are more efficient. This paper talks about working principles and components needed for the system and emphasizes its ability to give early warnings as well as trigger alarms and stop the compressor during severe conditions.

Keywords: Compressor, Sensor, Water detector

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1.0 INTRODUCTION

Marine environments and other industrial applications require maintenance of the main air compressor since it is responsible for providing compressed air to power equipment. The performance and longevity of the compressor are greatly affected by the quality of sump oil used as a coolant and lubricant. However, water contamination in sump oil can corrode, reduce efficiency of lubrication, leading to rapid wear of emulsions that can cause compressor failure. This paper describes how a water detector has been designed and implemented to detect water in the main air compressor lube oil offering real-time monitoring with instant alarms for prevention of major faults/damages to optimally keep working.

2.0 LITERATURE REVIEW

2.1 Water Contamination in Sump Oil

Some of the common operational issues faced due to water contamination in sump oil are as follows - Wang et al. (2015) presented the influence of such type and percentage on compressor damage caused by acceleration in oxidation, corrosion, anti-wear disfunction resulting from moisture content over 1 mass % (heat-induced water-in-oil concentrations). In this context, Smith and Davis (2018) demonstrated that water contaminating acidic compounds leads to emulsified oil breaking down the protective oil film resulting in mechanical wear.

2.2 Traditional Detection Methods

In the past, detection of water contamination in oils was generally done through regular oil sampling and laboratory analysis such as Karl Fischer titration and infrared spectroscopy (Jones & Harris 2017). These methods are relatively slower exercise since it lacks monitoring function for real-time detection and hence not so beneficial in case of hypothetical contamination happening suddenly.

2.3 Enhancement on Sensor Technology

The key component of routine monitoring is the ability to monitor motors continuously and in real time during operation, which has been conducted using modern sensor technology developed for sump oil water content analysis. Capacitive Sensors: This type of sensors detect variations in the dielectric property of oil-water mixtures, and they provide, on time, precise feedback (Lee & Kim 2020). These effects effectively detect water contamination through acoustic impedance variations using piezoelectric sensors (Zhang et al. 2019).

2.4 Industry Applications

Water detection systems in industrial compressors integration has been one of the main points for consideration. Real-time monitoring: Nguyen and Patel (2021) noted real time monitoring is used to control the costs of additional maintenance while also avoiding unnecessary downtime. They also stressed the importance of creating sensors that were resilient to extreme industrial environments.

2.5 Emerging Technologies

In the process of detecting water in sump oil, new methods such as fibre-optic sensors or microwave sensing technology are being developed. Fiber optic sensors were proposed by Kumar and Singh because of its high sensitivity, immunity to electromagnetic interference, microwave sensing used the selective absorption properties between water-oil mixture for precise detection contamination (Ramos et 2023).

3.0 PROCEDURAL

This project employs research and case studies to ensure the system functions as intended. Simulations using Proteus and C compiler demonstrate the functionality of water and oil level sensors in triggering alarms and stopping the air compressor.

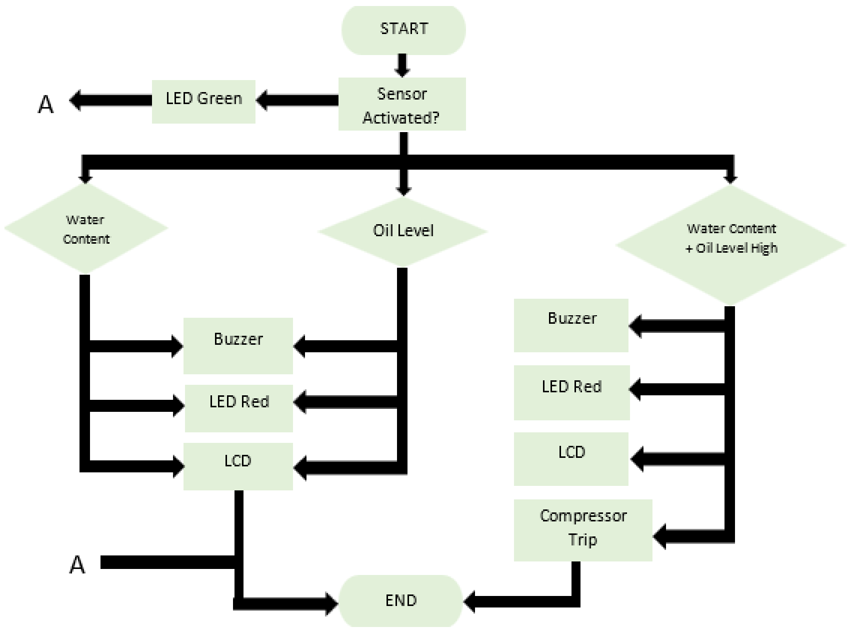

Fig. 1. WOIS system flowchart

Fig. 1 shows the flowchart of the WOIS system. The system operates by detecting water or oil levels exceeding set limits, triggering alarms, and potentially stopping the compressor. In Proteus, components such as MCU PIC16F84A, LEDs, sounder, LCD, toggle switches, and a motor (representing the compressor) simulate the system's functionality.

The simulation works by choosing the condition of the programmed either normal, bypass or off.

During normal operational normal, where no sensor is being triggered, a green indicator LED shall be on, and the display screen shall indicate "NORMAL." But should high water content or a high oil level trigger its sensor, an audible alarm turns on, and a yellow indicator light, along with the respective warning showing as “Water Content High” or “Oil Level High,” appears on the LCD, after which the air compressor continues to run.

In case of the detection of a high-water content and high oil level, it shall sound an audible alarm, a red LED, and indicate in the respective LCDs “Water/Oil Level High” and the air compressor shall then be turned off.

In bypass mode, it will only bypass the sensors to activate an audible alarm and trigger yellow LED. The LCD will display “BYPASS,” while the air compressor continues running normally.

If the system is in off condition, then the program will not work. In this condition, the air compressor will also work normally, no audible alarm or LED will be triggered, and in the LCD, “OFF” shall be displayed. Figure 2 illustrates the Proteus schematic circuit.

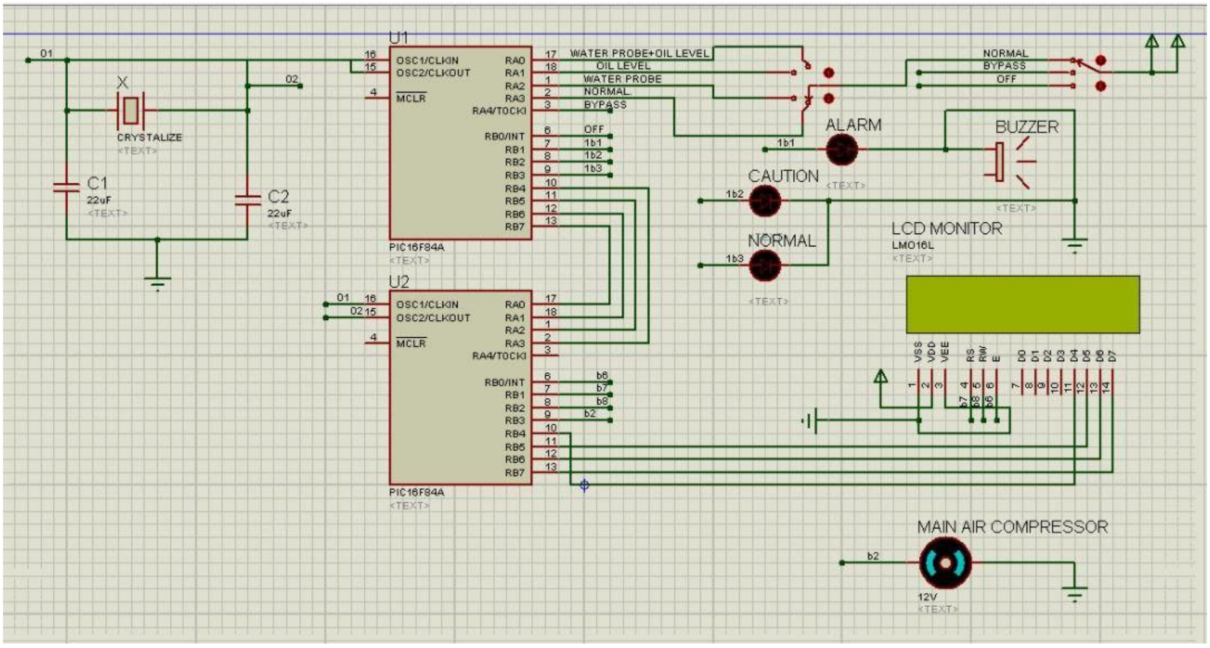

Fig. 2. WOIS Schematic circuit

The Table 1 below, outlines the operation of a Water Operating and Information System, detailing how its components respond to different conditions such as high water content, high oil levels, system status (on or bypass), and combined high water and oil levels. The Water Probe and Oil Probe activate independently when their respective thresholds are exceeded and simultaneously during the combined condition. The Buzzer and Red LED provide warnings in all high-level scenarios, while the Yellow LED remains inactive, indicating it is not used for these conditions. The Green LED signals normal operation, activating only when the system is on and no faults are present. The LCD Display provides real-time information under all conditions except when the system is bypassed. Additionally, the Compressor Trip is triggered only when both water content and oil levels are high, serving as a safety measure to protect the system. This setup ensures comprehensive monitoring, timely alerts, and protective actions to maintain operational safety and efficiency.

Table 1. The truth table of Water Operating and Information System

Component	Water Content High	Oil Level High	System On	System Bypass	Water Content + Oil Level High
Water Probe	1	0	1	0	1
Oil Probe	0	1	1	0	1
Buzzer	1	1	0	0	1
LED Red	1	1	0	0	1
LED Yellow	0	0	0	0	0
LED Green	0	0	1	0	0
LCD	1	1	1	0	1
Compressor Trip	0	0	0	0	1

4.0 RESULTS

The incorporation of MCU PIC16F84A is the fail-safe operation, input safety checks, emergency shutdowns, and feedback testing. Safety and easy maintenance are a bonus by the manual override toggle switch. The real-time data is displayed on the LCD screen resulting to alarms for efficient operations. The dual sensor integration makes sure that the data collected by the two sensors are cross checked hence eliminating cases of failure of one sensor while at the same time improving the quality of collected data.

5.0 CONCLUSION

The presence of moisture in the sump oil is one of the leading causes of poor performance and/or shorter working life of air compressors. Existing methods are slow and do not have the reactivity feature. Features in sensor technology: capacitive and piezoelectric sensors which are inexpensive, quick, real-time control and action. To achieve higher levels of accuracy and reliability future technologies such as fiber-optics and microwave technologies have been sighted for use in detection instruments.

The advanced water detector system for main air compressor sump oil is highly useful since it helps to eliminate expensive maintenance, the prevention of time wastage through unplanned for compressor loss, all while getting to prolong the lifespan of a valuable and costly machine. Such observation ensures that responses to water contamination are timely, hence, the best performance is achieved.

In conclusion, advanced water detection provides a significant development and integration in compressor maintenance. Further areas for research and innovation in this area are critical to improving the functionality of such systems for more robust assurance of more resilient and efficient industrial operations. Adopting such technology will significantly go a long way to safeguard the performance and reliability of air compressors for operation effectiveness in different industrial applications.

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From Simulators to Screens: A Critical Review of Online Distance Education in Maritime Education and Training

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Abstract - The COVID-19 pandemic has catalysed a transformative shift in the maritime training sector, driving the transition from traditional physical simulators to cloud-based solutions. This research critically examines the complexities of this transition, focusing on the fidelity of simulators, practical applications, and empirical evidence. The review traces the origins and evolution of online distance education (ODE), highlighting its increasing relevance in modern Education. Simulator fidelity, encompassing physical and functional accuracy, emerges as a crucial factor for effective training. Cloud-based simulators offer notable benefits, including accessibility, scalability, and cost-effectiveness; however, their ability to replicate the fidelity of traditional simulators requires further empirical validation. Current initiatives by simulator manufacturers and quality standards organisations demonstrate a readiness to adopt cloud-based solutions, yet empirical studies reveal challenges such as prolonged exercises and engagement issues. Identified research gaps include the need for comprehensive empirical validation, longitudinal impact studies, standardisation efforts, and cost-benefit analyses. Recommendations for future research emphasise comparative studies, quantitative assessments, ergonomic integration, and robust feedback mechanisms. Addressing these gaps will enhance the understanding and implementation of cloud-based simulators, ultimately advancing the quality and accessibility of maritime training

Keywords: Cloud-based Simulator, Maritime education and training, MET, Simulator Fidelity, Online Distance Education, ODE

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1.0 INTRODUCTION

In recent years, the education sector has experienced a significant and transformative change on a global scale. This change has been further accelerated by the exceptional difficulties posed by the COVID-19 epidemic (UNESCO, 2020). During this change, the field of maritime training serves as evidence of adaptation, where the combination of necessity and creativity has resulted in the rethinking of traditional teaching methods (Bartusevičienė et al., 2021). This essay explores the complexities of converting practical training with maritime simulators into online distance education (ODE), a shift prompted by the demands of the pandemic era.

The maritime industry, renowned for its stringent training standards, has traditionally depended on physical simulators to instil vital skills and competencies in seafarers. Nevertheless, the emergence of COVID-19 has disturbed traditional teaching methods, making it impossible to access traditional classrooms and physical simulators. As a result, educators and industry stakeholders felt the need to consider different options, leading to the introduction of cloud-based simulators (Knysh & Dudziak, 2020).

This transition emphasises the maritime industry's ability to recover quickly and the broader importance of adjusting to digital methods in Education. As we move through this transformation, it is crucial to carefully examine both the theoretical foundations and the actual implementations propelling this change. By connecting academic research with practical application, we thoroughly comprehend the difficulties, possibilities, and consequences of combining technology and Education.

This essay explores the complex intricacies of transitioning maritime training from simulators to screens by integrating empirical study findings, practical implementations, and theoretical frameworks. Our goal is to shed light on the way ahead, where adaptation, collaboration, and inventiveness come together to alter the boundaries of ODE in the marine field and beyond

2.0 CRITICAL REVIEW

2.1 The origin of ODE

The origins of distance learning may be traced back to the 19th century when correspondence courses developed as an innovative educational strategy (Masalimova et al., 2022). Institutions such as the University of London were the first to introduce this approach, which allowed students to receive educational materials, submit assignments, and contact professors using postal services. This initial iteration of remote instruction established the groundwork for further advancements.

During the 20th century, distant learning expanded its scope by including radio and television broadcasts. Platforms like "University of the Air" employed various platforms to disseminate educational content to a broader audience (Simonson, 2021). The availability of radio and television facilitated the distribution of instructional resources on diverse topics, representing a notable advancement in distance learning.

The 1960s saw the emergence of open universities, a revolutionary idea aimed at enhancing the flexibility and accessibility of Education. The UK Open University, established in 1969, emerged as a pioneer in this endeavour (Weinbren, 2015). Open universities employed a blend of printed resources, broadcasts, and in-person tutorials, showcasing a dedication to diversity and catering to a wide range of learners.

The 1990s witnessed a paradigm shift with the emergence of the internet, which laid the foundation for the development of online Education. Learning Management Systems (LMS) such as Blackboard (Ménard, 2022) and Moodle (Moodle 2020) have enabled the online delivery of courses, either fully or partially. This transition facilitated instantaneous connection and seamless multimedia and non-simultaneous learning integration, offering enhanced student adaptability and broadening remote Education's scope.

The 2010s witnessed the emergence of Massive Open Online Courses (MOOCs), significantly challenging conventional education paradigms (Bates, 2015). Platforms like Coursera, edX, and Udacity have partnered with prestigious universities to offer free or reasonably priced online courses to a large worldwide audience (Dhawal et al., 2023). MOOCs prioritised accessibility, interactivity, and self-paced learning, promoting the democratisation of Education worldwide.

Over the past decade, traditional distance learning has evolved into ODE. This instructional method employs digital technologies to provide educational content and support learning for students physically far from the instructor or educational institution (Bates, 2015). ODE enables learners to access course materials, participate in conversations, and engage in learning activities through digital platforms, reducing the requirement for physical presence in a conventional classroom environment.

ODE encompasses critical features such as asynchronous learning, allowing students to engage with course materials at their preferred speed, and synchronous elements, such as live lectures or virtual classrooms, which aim to facilitate real-time interactions and foster a sense of community among learners (Aretoulis et al., 2023). Incorporating multimedia components, online discussion forums, and collaboration tools improves the overall educational experience in the digital setting. Mobile devices have become essential in modern times, incorporating mobile learning into distance education. Individuals can retrieve instructional material at any given time and location, promoting a constant and ongoing process of acquiring knowledge. Furthermore, the increasing popularity of microlearning, consisting of brief and targeted learning modules, has become prominent, meeting the needs of contemporary learners with limited time.

ODE has emerged as a prominent element of modern Education, propelled by technological improvements and the growing need for adaptable learning alternatives (Baepler et al., 2014). It pertains to providing Education using digital platforms, enabling learners to access educational content remotely. This discussion examines and assesses three developing trends in ODE, specifically emphasising their potential influence on educational practices, learner experiences, and institutional tactics.

2.2 Simulator fidelity

Oliveira et al.'s (2022) systematic literature review offers valuable insights into the parameters of simulator fidelity and their implications for training efficacy in the maritime environment. The paper primarily examines the accuracy and functionality of traditional simulator settings. Still, it also discusses how these findings might be applied to ODE, precisely the effectiveness of cloud-based simulators.

The arrangement of the bridge and visual system, as emphasised in the review, is essential to physical accuracy in maritime simulators (Kim et al., 2021a). The prioritisation of expansive visual fields and detailed representations emphasises the need to establish an immersive environment that promotes efficient training. Regarding ODE, moving from physical simulators to cloud-based solutions requires careful thought about how these ergonomic elements might be used in a virtual environment (Hjellvik & Mallam, Jan 1, 2021). Cloud-based simulators must accurately reproduce authentic ship configurations and visual systems while guaranteeing effortless access and user engagement via online interfaces.

Functional fidelity refers to the degree to which a training programme accurately represents the actual tasks and demands of a specific job or activity (Oliveira et al., 2022). It is an essential consideration in designing training programmes, as programmes with high functional fidelity are more likely to prepare individuals for real-world performance effectively. Therefore, while designing a training programme, it is crucial to ensure that the programme.

Cloud-based simulators have distinct benefits in providing dynamic and customisable training programmes within ODE. Virtual sessions can be created to replicate different maritime situations, enabling trainees to participate in hands-on learning regardless of their geographical location. A study by Kim et al. (2021) comprehensively evaluates the characteristics of a cloud-based maritime simulator using the SWOT analysis approach (Table 1), while another study by Tusher et al. (2023) supports this SWOT analysis by showing that cloud-based simulators are considered less desirable when emphasising educational value, but become the most desirable choice when focusing institutional capacity and possibility of remote training (Figure 1).

Table 1 Cloud-based maritime simulator SWOT analysis (by Kim et al., 2021b)

Type of simulator	Internal factors		External factors	
	Strengths	Weaknesses	Opportunities	Threats
	VR.S5 - Real-time feedback from trainees (AR)	VR.W5 - Limited team cooperation and interaction		VR.T4 - Danger of technology hype VR.T5 - Technological acceptance barriers
Cloud-based (CB) simulator	CB.S1 - Ubiquitous learning CB.S2 – Self-directed CB.S3 - Less capital intensive CB.S4 - Limited maintenance of hardware CB.S5 - No need of physical presence	CB.W1 - Lack of social interaction CB.W2 - Lack of formative assessment CB.W3 - Limited transfer of learning, unclear application in MET CB.W4 - Lack of team training opportunities	CB.O1 - Geographically separated synchronous learning CB.O2 - Novel mode of training and assessment CB.O3 - Possible use in post COVID-19 era CB.O4 - Highly scalable	CB.T1 - Cyber security CB.T2 - Lack of institutional support CB.T3 - Internet connectivity and speed barriers

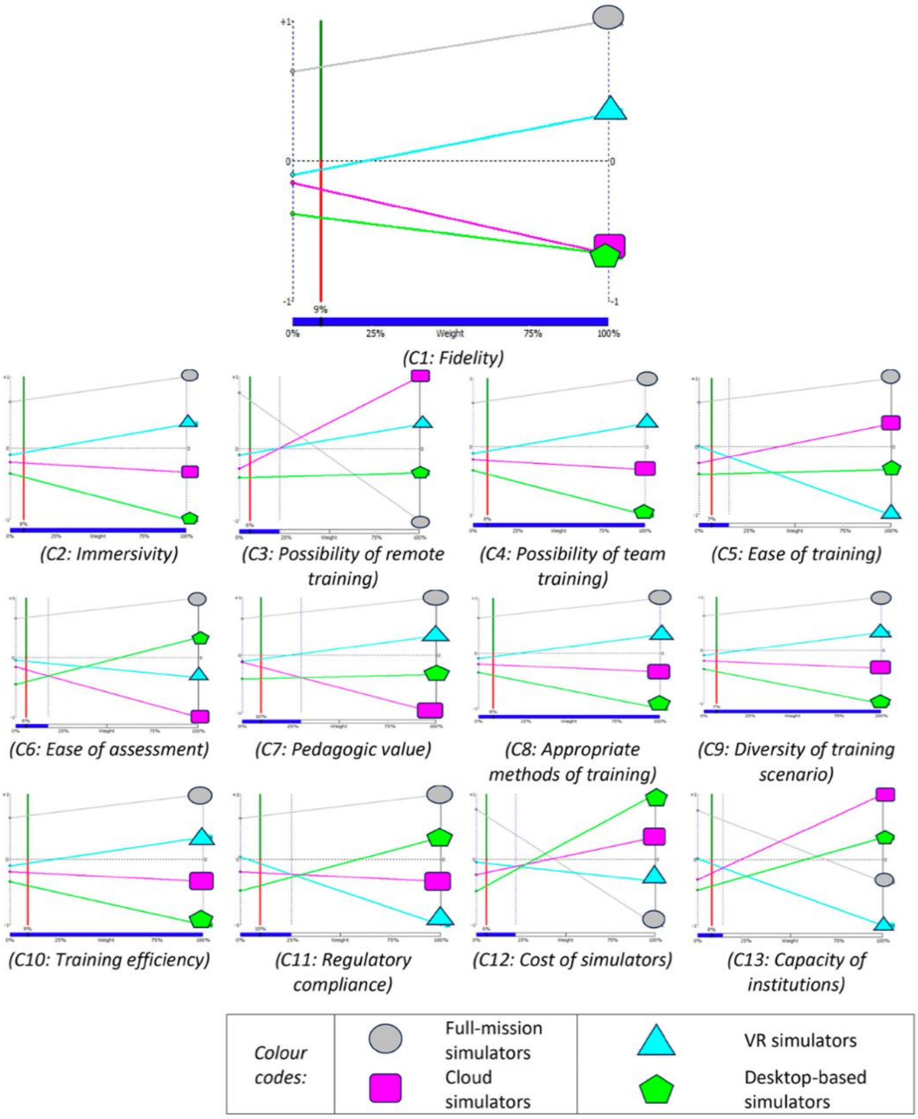

Figure 1 Comparison of maritime simulators sub-criteria (by Tusher et al., 2023)

The evaluation highlights the necessity of adopting a more complete methodology to evaluate the accuracy of simulators and their influence on training results. Although traditional full-mission simulators have been preferred for their high level of accuracy, the extent to which cloud-based simulators may achieve similar training results has not been thoroughly investigated. Cloud-based solutions provide the advantages of scalability, accessibility, and cost-effectiveness, making them appealing choices for online distance education (Kim et al., 2021c). Nevertheless, additional empirical validation is needed to confirm their ability to replicate traditional simulators' physical and functional accuracy.

The review recommends that future research prioritise quantitative studies that isolate individual aspects of simulator fidelity and assess their influence on training outcomes. This approach is specifically applicable for evaluating the effectiveness of cloud-based simulators in online distance education. Conducting comparative analyses between traditional and cloud-based systems can yield significant insights regarding the advantages and constraints of each approach. In addition, standardising language and broadening the geographical range of study can improve the applicability of findings and provide a more comprehensive comprehension of simulator accuracy in various circumstances.

The systematic study thoroughly examines the accuracy and realism of simulators in the maritime field. Its findings also have relevance to the changing field of online distance education. Cloud-based simulators have significant prospects for improving accessibility, flexibility, and scalability in marine training. However, the usefulness of simulators depends on their capacity to recreate traditional simulators' physical and functional characteristics accurately. Future studies should focus on closing this gap and thoroughly investigating the possibilities of cloud-based solutions in determining the future of maritime Education.

2.3 Practical applications

2.3.1 Simulator manufacturers with cloud simulation

Simulator makers, training providers, and quality standard organisations are highly prepared to use cloud-based solutions for maritime training. This readiness is mainly driven by the difficulties caused by the COVID-19 pandemic. The summary of the preparedness of each entity:

2.3.1.1 DNV

DNV has acknowledged the growing need for remote training methods during the pandemic and has developed a new certification, called simulator class D, to address cloud-based distant learning simulators that require virtual reality (VR). This project entails working with simulator suppliers and end-users to guarantee adherence to international requirements and legislative restrictions. DNV prioritises upholding elevated levels of authenticity and conduct in remote simulation settings, particularly concerning the facilities provided for instructors and assessors (DNV, 2021).

2.3.1.2 Kongsberg

Kongsberg Digital has recently introduced K-Sim Navigation CLOUD, a navigation simulation solution that operates in the cloud and is specifically built to comply with DNV's Class D standards. No text was provided. The system offers institutes flexibility through fundamental navigation training, the integration of blended learning opportunities, and the availability of stand-alone simulation exercises. Kongsberg Digital utilises sophisticated physics engines, hydrodynamic modelling, and visual systems powered by Unreal Engine to provide very realistic training experiences (Digital Ship, 2023).

2.3.1.3 Wärtsilä Voyage

Wärtsilä Voyage provides an affordable Ocean Learning Platform incorporating simulation capabilities to verify and enhance seafaring personnel's essential navigational and engine room skills. The platform minimises the requirement for physical simulators, travel expenses, and time spent away from family, allowing for more frequent utilisation of simulations for planning, training, and assessment. By incorporating simulations into the Ocean Learning Platform, Wärtsilä Voyage enhances the link between experience learning and other learning methods, like e-learning and evaluations (OCEAN Technologies Group, 2023).

2.3.1.4 FORCE Technology

FORCE Technology offers SimFlex Cloud, which allows users to assess port designs and offshore renewable projects through online engineering studies. The simulator provides sophisticated functionalities and lifelike simulations to fulfil hardware and software prerequisites. SimFlex Cloud enables data-driven and resource-optimised decision-making by visually representing the benefits and constraints of proposed port designs in real-world scenarios (FORCE Technology, n.d.).

2.3.1.5 Thet A Marine

Thet A Marine provides the Wärtsilä Voyage Cloud Simulation as a highly efficient method for delivering classroom training remotely. The cloud simulation platform offers access to maritime and technology simulators, such as ECDIS, radar, engine room, and liquid cargo handling that meet the standards set by IMO and STCW. This programme enhances learning opportunities by offering immediate access to simulators outside conventional training facilities (Thet A Training Center, 2023).

2.3.2 Summary

In summary, these initiatives illustrate a collaborative endeavour by simulator manufacturers, training providers, and quality standard bodies to adopt cloud-based solutions and adjust to the changing requirements of the maritime industry, specifically in light of the difficulties posed by the COVID-19 pandemic.

2.4 An empirical study

Gyldensten et al. conducted a study on the effectiveness of cloud-based simulators. The study included video recordings and interviews with deck cadets students to gain insights into their encounters with a cloud simulator for navigation training (Figure 2). A total of 22 students were selected for the study, comprising two distinct groups: first-year students who were being taught fundamental navigation skills and third-year students who had more advanced knowledge of the subject. Students predominantly engaged in independent work throughout the simulations, with minimal peer interactions. After completing the tasks, the students were interviewed regarding their opinions.

Figure 2 Workstation for video recording *(by Gyldensten et al., 2023)*

In general, students expressed satisfaction with the availability of the cloud simulator; however, there were variations in their enthusiasm. First-year students exhibited a variety of emotions, but none of them stated any negative opinions. The users regarded the simulator as beneficial for acquiring knowledge of navigation equipment and admired its adaptability. Nevertheless, several pupils perceived the exercises as excessively lengthy and the waiting periods demoralising, resulting in diversions.

The students responded favourably to the text-based briefings that preceded the exercises and found the independent learning approach conducive to their comfort. They were receptive to digital debriefing forms but had reservations about their effective implementation. Many students expressed that the cloud simulator adequately equipped them for the complete mission simulator and desired exercises that aligned with the learning objectives of the whole mission.

Ultimately, the study demonstrated that students appreciated the cloud-based simulator’s adaptability and readiness for more advanced training. However, they encountered difficulties with the duration of the exercises and their level of involvement. They proposed enhancements to decrease waiting times and improve the learning experience.

2.5 Integration of research and practice

The amalgamation of scholarly theories (research) with real-world applications in the maritime training industry, explicitly concerning cloud-based simulators, uncovers both areas of agreement and points of dissent.

2.5.1 Alignment

I. DNV's Certification Initiatives: The research findings, especially those highlighting the significance of simulator accuracy and capability, have impacted the creation of new certification criteria by organisations such as DNV. The introduction of simulator class D certification is in line with findings from research, recognising the necessity for immersive and functionally precise cloud-based simulators to guarantee efficient training.

II. Manufacturer offers: Companies that produce simulators, such as Kongsberg Digital, Wärtsilä Voyage, FORCE Technology, and Thet A Marine, have adjusted their product offers to match the research results and meet certification standards. For instance, Kongsberg Digital's K-Sim Navigation CLOUD and Wärtsilä Voyage's Ocean Learning Platform combine sophisticated physics engines, hydrodynamic modelling, and visual systems to offer authentic training experiences that accurately replicate real-life scenarios, aligning with the focus on simulator accuracy emphasised in research.

2.5.2 Divergence:

I. Empirical Studies vs. Practical Experience
Empirical studies offer helpful insights into the valuable efficacy of cloud-based simulators, but actual experiences may uncover issues not represented in research. Gyldensten et al.'s research on maritime students' utilisation of cloud-based simulators revealed unanticipated challenges, like prolonged exercises and waiting times, which theoretical studies may not have entirely predicted.

II. Perspectives of Training Providers
The practical execution can differ depending on the viewpoints and priorities of the training providers. Although research highlights the significance of simulator fidelity and functionality, training providers may prioritise cost-effectiveness, scalability, and convenience when choosing cloud-based solutions. This may result in variations in how implementation approaches are carried out compared to theoretical advice.

There is a substantial agreement between academic theories and practical applications regarding using cloud-based simulators for maritime training. The research findings have impacted the certification criteria and product offerings of simulator makers, demonstrating a mutual recognition of the significance of simulator accuracy and capabilities. Nevertheless, there are differences in several aspects, particularly in converting research findings into practical applications and the diverse viewpoints of training providers. To effectively integrate research and practice in maritime training, it is crucial for researchers, practitioners, and certifying organisations to collaborate and work together.

2.5.3 Implications for Future Practices

Integrating research and practical application in implementing cloud-based simulators for maritime training has significant implications for the future of online distance education.

I. Improved accessibility and increased flexibility
Maritime training can be improved by using cloud-based simulators, which provide increased accessibility and flexibility. This allows seafarers to access top-notch training materials no matter where they are located. This comprehensive comprehension underscores the significance of using technology to surmount educational obstacles, facilitating the adopting of more inclusive and accessible practices in online distance education.

II. Economic efficiency and expandability
Using cloud-based solutions, training providers can diminish expenses linked to physical infrastructure and travel, enhancing the cost-effectiveness and scalability of marine training. The comprehensive comprehension emphasises the capacity of cloud-based technology to democratise education and broaden the availability of training opportunities for seafarers globally.

III. Ongoing Enhancement and Advancement
Integrating research insights with practical implementation cultivates a perpetual enhancement and ingenuity culture in online distance education. Training providers can enhance and improve cloud-based training programmes for seafarers and the maritime sector by combining input from empirical studies and practical experiences.

IV. Standardisation and Quality Assurance
Collaboration among academic researchers, industry practitioners, and certification authorities enables the establishing of standardised training techniques and guarantees quality assurance in online distance education. This comprehensive knowledge highlights the significance of matching theoretical frameworks with industry standards and best practices to maintain the integrity and efficacy of maritime training programmes.

V. Integration with Technological Advancements
The comprehensive comprehension of simulator training conducted through cloud-based platforms influences future practices by promoting adapting to technology changes. To keep up with the ever-changing landscape of technology, training providers must be adaptable and quick to respond to new trends and advancements in online distance education. They aim to give seafarers pertinent, captivating, and efficient training to equip them for real-life obstacles.

3.0 CONCLUSION

To summarise, the progression of remote learning from its modest origins in the 19th century to the contemporary era of ODE has been characterised by notable breakthroughs in technology and instructional approaches. The trip has been marked by integrating several forms of communication, such as postal services, radio, television, and the internet, all of which have contributed to the growth and diversification of educational options. The advent of ODE in the 21st century has fundamentally transformed conventional learning paradigms, providing students with unparalleled flexibility, accessibility, and involvement.

Several new trends in the field of ODE have the potential to significantly impact educational methods, learner experiences, and institutional initiatives. Microlearning, which prioritises the delivery of concise and targeted learning modules, accommodates the preferences of modern learners and encourages active participation and adaptability. Nevertheless, educators should remain cautious of certain disadvantages, such as oversimplification and inadequate context, to guarantee a well-rounded approach to curriculum design.

Overall, analysing academic research and real-world application of cloud-based simulators for maritime training emphasises the need to combine theoretical knowledge with actual execution to create online distance education's future. Notable findings from this analysis include the significance of simulator accuracy and capabilities, the possibility of cloud-based solutions to improve accessibility and flexibility, and the requirement for ongoing enhancement and innovation in training methods. In the future, this integration will be essential in shaping online distance education by encouraging cost-effectiveness, scalability, standardisation, and quality assurance in maritime training programmes. By utilising technology and adopting collaborative methods, the maritime sector can guarantee that seafarers receive top-notch training that equips them with the necessary skills and abilities to negotiate the complexities of the modern marine environment. Integrating research and practice in online remote Education is a transformative shift that enhances the dynamic, accessible, and practical training paradigm.

The research identifies several gaps in the transition to cloud-based maritime simulators. There is a need for comprehensive empirical validation to ensure these simulators can match the fidelity of traditional ones. Additionally, longitudinal studies are necessary to understand the long-term impacts of using cloud-based simulators. Efforts to standardise these systems and conduct thorough cost-benefit analyses are also required. By addressing these gaps through comparative studies, quantitative assessments, ergonomic integration, and robust feedback mechanisms, the effectiveness and implementation of cloud-based simulators in maritime training can be significantly improved

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Informational of Qualification in Welding for SMAW Process: A Meta-Analysis

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Abstract - Informational of qualification and known as reference providing the instruction, guidance and support to any organization or personnel for the purpose of qualification test in welding. Currently, the requirement of qualification in welding is available in both sectors of government technical institute (TVET) and industries. The most common welding process, versatile and normally conducted in both sectors is Shielded metal Arc Welding (SMAW). This isimportant that the execution of processes is to be addressed in detail and this information will be a pillar in making the qualification test successful. The aim of this meta-analysis is to determine, investigate and further encompass the best practices together with the suggestions which can be implemented during the qualification test session.

Keywords: - Informational, Meta-Analysis, Qualification Test, Welding, SMAW,

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1.0 INTRODUCTION

Welding is one of the processes used to permanently join two or more solid components. This can be achieved by heating the material to the welding temperature, with or without the application of pressure, and with or without the use of filler material. Alternatively, welding can be defined as a fabrication process where two or more parts are fused together by means of heat, pressure, or both, forming a joint as the parts cool. Welding is typically used on metals and thermoplastics, but it can also be applied to wood. The completed welded joint may be referred to as a weldment (TWI, 2020)

The qualification test in welding is a crucial part of Quality Assurance. In accordance with the requirements of ISO 9001 for product quality, the compliance and conformity of products involving welding are highlighted topics for implementation. Compliance and conformity in welding are interpreted as ensuring that all welding activities are performed according to established guidelines, codes, and regulations. These established guidelines and references set out the requirements for any organization and its responsibilities to provide qualifications through applicable procedures and performance tests in welding. There are several international references of codes and standards, such as American Standards, European Standards, and Japan Industrial Standards, which are commonly used in both local and global markets (Prajadhiana et al., 2018).

2.0 IMPORTANT INFORMATION

Qualification Test Environment

A qualification test in welding refers to the initial and essential scope of work that validates the abilities and weldability of the test results, thereby providing acceptance of the overall work process. The work activities are primarily based on instructional references such as:

1) Welding Procedure Specification (WPS) - This is based on supporting Procedure Qualification Records (PQR), which are initially established from preliminary documents.

2) Welding Qualification Test (WQT) - This is conducted as per the reference of a certified WPS.

Both above qualifications have their own targets, which can be finalized within the qualified range. If a qualification is found to be out of range, a new qualification will be required. The process of completing a qualification test involves various parties who verify, test, and witness the entire activities.

This study aims to:

1. Compare single-phase and three-phase welding machines.

2. Examine the characteristics of SMAW electrodes with the same classification but from various brands.

3. Determine the cumulative duration of experience and knowledge required to perform the process.

4. Identify potential forms of support needed for success.

From the above items 1, 2, and 3, further studies and findings will be determined to elaborate on the results.

Table 1. shows the summaries of studies

No.	Description	Study for
1	Welding machines	Comparison between single and three phase- to include advantages and disadvantages from the perspective for qualification purposes. - Frequency and long-term duty of operational. - Stability, control and handling. Recommended current and polarity use for welding.
2	Selection of Material and Consumables	Specification and Grade of Steels and condition of supply. Manufacturer/ brand-named of SMAW electrodes and its characteristic Specification and Grouping number of SMAW electrode. Test result of quality and its properties.
3	Knowledge and experiences	Body of knowledge and skills required. Cumulative traveling time (hours, days, months and years) as required prior to performing the qualification.

Table 1 summarizes several studies related to welding machines, the selection of materials and consumables, and the required knowledge and experiences in the welding field.

The first part of the table focuses on welding machines. It compares single-phase and three-phase welding machines, discussing their advantages and disadvantages, particularly for qualification purposes. This comparison includes considerations of operational frequency, long-term use, stability, control, and handling. Additionally, the study offers recommendations on the appropriate current and polarity settings for welding.

The second part of the table addresses the selection of materials and consumables. It details the specifications and grades of steel, including their supply conditions. The study also lists the manufacturers or brand names of Shielded Metal Arc Welding (SMAW) electrodes, describing their characteristics. Further, it specifies and groups the numbers of these electrodes, and includes test results concerning their quality and properties.

The third part of the table covers the necessary knowledge and experiences for welding. It outlines the essential body of knowledge and skills required for the field. Moreover, it specifies the cumulative time needed for travel (measured in hours, days, months, and years) before one can qualify to perform welding tasks.

Overall, the table provides a detailed overview of important studies that are crucial for understanding various aspects of welding, from machine types and material selection to the knowledge and experience needed for effective welding practices.

Table 2: Show for the Studies of Qualification in Welding

No.	Study	Research Purposes	Type of References	Support Form of Informational to The Qualification in Welding for SMAW Process.							
				Welding Machine		Selection of Material and Consumables				Knowledge and experiences	
				Welding Machine; Single and Three Phase	Durability of use; stability, frequency and long-term duty of operation.	Steels and condition of supply	Manufacturer/ brand name and its characteristics.	Grouping number of SMAW electrode.	Test result of quality and properties.	Body of knowledge and skills required.	Cumulative duration of experiences (hours, days, months, and years) as required prior to performing the qualification.
1	M. PITA1 & M. MAUMELA 2, 2021	The Effect of Different Brands of Welding Electrode on The Mechanical Properties of Welded Joints in Mild Steel.	Research Paper				√				
2	P Hargiyarto, K Syauqi, S Sugiyono, A Ardian, S Sianipar and LA Nadjib, 2020	Analysis of quality student practice results in shielded metal arc welding.	Research Paper							√	√
3	American Society of Mechanical Engineer (ASME) IX	Part QW Article IV Welding Data-P-Number (Assigned Group of Basemetal)	International Code and Standard			√					
4	American Society of Mechanical	Part QW Article IV Welding Data F-Number	International Code and Standard					√			

	Engineer (ASME) IX	(Assigned Group of Filler Metal)									
5	American Welding Society (AWS) D1.1- Structural Welding Code_Steel	Section 6, Table 6.8 & Table 5.9 of Listed and Unlisted Base Metal	International Code and Standard			√					
6	American Welding Society (AWS) D1.1-Structural Welding Code Steel	Section 6, Table 6.5 of PQR Essential Variable and Table 6.13 Electrode Classification Group	International Code and Standard					√			
7	American Society of Mechanical Engineer (ASME) II	Part A- Ferrous Material Specification.	International Code and Standard			√					
8	American Society of Mechanical Engineer (ASME) II	Part C- Specification for Welding Rods, Electrodes and Filler Metals.	International Code and Standard					√	√		
9	Sijil Kemahiran Malaysia (SKM)	SKM Level 1, Level 2, Level 3, Level 4	National Occupational Skills Standard (NOSS)							√	√
10	CIDB Malaysia	Certification Scheme for Welding Level 1, Level 2, Level 3	CIDB-Book_Cs01-Welding							√	√
11	S.Farrukh Haider 1, M.M. Quazi 2, Jahanzeb Bhatti 3, M Nasir Bashir4*, Imran Ali 5, 2019	Effect of Shielded Metal Arc Welding (SMAW) Parameters on mechanical properties of	Research Paper							√	
12	Adino Amare, Arumugam Balasuadhaka	Performance analysis of a low power	Research Paper	√	√						

	r*, and Hailemichael Solomon, 2023	consumption electric arc welding machine constructed using cost effective materials.									
13	Kobelco Welding Handbook, 2016	Suitable current and polarity for SMAW electrode.	Welding Handbook (Manufacturer)			√	√	√	√		
14	Megmeet Welding Technology	Three-phase Welding machine VS. Single-phase Inverter Welding Machine	News	√	√						
Total Frequency				**2**	**2**	**4**	**2**	**4**	**3**	**4**	**3**

Table 2 provides a comprehensive overview of various studies related to qualification in welding, focusing on the Shielded Metal Arc Welding (SMAW) process. Each study is categorized by its purpose, type of reference, and the specific support it provides for different aspects of welding qualification, such as welding machines, material selection, and the required knowledge and experience.

The first study by M. Pita and M. Maumela (2021) explores the effect of different brands of welding electrodes on the mechanical properties of welded joints in mild steel. It is a research paper that supports the use of specific welding machines. The study by P. Hargiyarto and colleagues (2020) analyzes the quality of student practice results in SMAW, focusing on knowledge and experiences required for welding, and is also a research paper.

Several international codes and standards are included in the table, such as those from the American Society of Mechanical Engineers (ASME) and the American Welding Society (AWS). These documents provide specifications and grouping numbers for materials and electrodes, and test results of quality and properties. For instance, ASME IX and ASME II parts A and C provide detailed welding data and material specifications, while AWS D1.1 details structural welding codes and essential variables for procedure qualification records (PQR).

The table also references national standards and certification schemes, such as the Sijil Kemahiran Malaysia (SKM) and the Construction Industry Development Board (CIDB) Malaysia, which outline the levels of certification and the body of knowledge and skills required for welding.

Other studies and resources, like the Kobelco Welding Handbook and news from Megmeet Welding Technology, offer practical information on suitable currents, polarity for SMAW electrodes, and comparisons between different types of welding machines.

Overall, the table lists various types of references, including research papers, international codes and standards, national occupational skills standards, and manufacturer handbooks. These references collectively support the qualification process for SMAW by providing critical information on welding machines, material selection, and the necessary knowledge and experiences.

Welding Machine

1) Single phase and three phase of welding machine.
2) Durability of use; stability, frequency and long-term duty of operation.

A three-phase welding machine is a type of equipment that uses a three-phase electrical power supply to generate the required welding current and voltage. This machine, known for its high-power output, stability, and efficiency, is ideal for heavy-duty welding applications in industries such as construction, shipbuilding, and large-scale fabrication. Its robust design, superior heat control, consistent arc stability, and ability to handle prolonged operations without overheating make it a staple in industrial workshops.

Conversely, a single-phase inverter welding machine uses a single-phase electrical power supply and employs inverter technology to convert this input power into a controlled output. This technology allows for better control over the welding arc and output characteristics. These machines are compact, portable, and energy-efficient, making them suitable for a wide range of welding tasks, including light to medium-duty applications. They are favored for their versatility, ease of use, and ability to produce high-quality welds with improved arc stability(Dagmar & Suseno, 2023).

A recent study by Adino Amare (2023) serves as a comprehensive reference for both single-phase and three-phase power supply arc welding machines (Das et al., 2020). The study was conducted to address power and cost-related issues. The findings revealed that under welding conditions, there were no additional losses. The efficiency of the local arc welding machine, characterized by its compact transformer construction, optimal material selection, and fan cooling system, was evaluated while operating on a single-phase supply. The machine demonstrated superior performance, providing significant value in terms of power output and durability for long-term operation.

Manufacturer/ brand name and its characteristics.

- Comparison of SMAW electrode with the same classification and various brand-named.

A comparison of SMAW electrodes with the same classification but different brand names was conducted by researcher (Hafni, 2021) The study found that the brand name of the SMAW electrode significantly impacts the welding outcome, even when the process parameters and handling remain the same. This was particularly evident when welding a 10.0mm thick base metal (mild steel) with an E6013 electrode of size 3.2mm. The study also noted differences in the width of the Heat- Affected Zone (HAZ) and weld metal when comparing hardness curve results.

The characteristics of a welding electrode are crucial in selecting the appropriate welding method for any type and specification of pipe or steel structure. As per the Kobelco Welding Handbook (KOBE STEEL, LTD., Welding Business Marketing Department) (KOBELCO, 2022) each electrode is specifically designed for a target welding position. For instance, the commonly used SMAW electrode E7018 is suitable for all kinds of welding positions. The handbook also provides recommended current and polarity based on the size of the electrode, serving as a guideline for organizations to develop welding procedures and qualification tests

Knowledge and experiences.

According to a study by (Hargiyarto et al., 2020) an analysis of the SMAW process practiced by 18 Diploma III Mechanical Engineering students from the Faculty of Engineering, Yogyakarta State University, revealed that none passed the visual test. The assessment results, with a rate below 50%, highlighted the importance of experience, knowledge, and welding competence in meeting industry standards.

Meanwhile, The National Occupational Skills Standard (NOSS)("Benchmarking Analysis of Occupational Standards for The Malaysia's National Occupational Skills Standard (NOSS) Approach

Towards New-Collar Jobs Era," 2022), under the Sijil Kemahiran Malaysia (SKM) and Jabatan Pembangunan Kemahiran (JPK), provides guidelines based on the needs of skilled personnel in Malaysia. A review by the TVET institution ILPIPOH (2023) (5) indicated that NOSS addresses work needs and career structures in specific fields, prepared by a pool of industry specialists, experts, and skilled workers. For instance, the Welding Technology course for SKM level 3, which lasts about 2 years and 3 months, exposes students to theoretical and practical knowledge about workshop practices, fabrication drawing, SMAW, FCAW, GTAW, GMAW process fundamentals, hands-on welding for plate and pipe, basic entrepreneurship, and industrial training sessions.

Other than that, The Construction Industry Development Board (CIDB, 2016) also offers a welding training course under its Certification Scheme for Welding. The course covers training, assessment, and examination for Welding Levels 1, 2, and 3. CIDB provides further training and examination for personnel with a minimum of six months of work experience or a valid Level 3 welding certificate from other training agencies. The certificate has a maximum validity of three years, with a revalidation process available.

In contrast, a study by (Chiong et al., 2019) investigated the effect of SMAW parameters on the mechanical properties of low-carbon steel, mild steel, and stainless-steel welded joints. The research showed that varying the welding parameters significantly affected the mechanical properties of different steel joints. Higher hardness values necessitated further heat treatment to prevent brittle fracture. The study concluded that more consideration should be given to input and output parameters to improve the material properties during welding.

Selection of Material and Consumables

According to the international standard stated in The American Society of Mechanical Engineers ("AMERICAN SOCIETY OF MECHANICAL ENGINEERS," 1899; Z., 1940) Section IX of ASME contains requirements for the qualification of various operators and the material joining processes they use during operations for the construction of components under the rules of the ASME Boiler and Pressure Vessel Code, the ASME B31 Codes for Pressure Piping, and other codes, standards, and specifications. The cross-section reference QW-420 in ASME IX addresses the listed material and assigns it a 'P' number, an alphanumeric designation used to reduce the number of qualifications required when materials or steel are involved in welding. Materials produced under various standards can be defined in Table QW/QB-422 and are considered equivalent using the Unified Numbering System (UNS) number.

Another reference available for the selection of steel for qualification purposes based on the application of steel structural is as per American Standards (American Welding Society (AWS) D1 Committee on Structural Welding, 2020) (2). This code, developed by the AWS D1 Committee on Structural Welding, is used for any steel thickness with a minimum of 3.0mm and specified minimum yield strength of 100 ksi (690 Mpa) or less. The cross-reference and section available for material under the 2020 edition is as per Section 6, Table 6.8 & Table 5.9 of Listed and Unlisted Base Metal. Approved base metals are grouped under various groups with references to material specification, grade, minimum yield strength, and tensile range. However, the range of qualifications for the use of unlisted steel is specifically accepted only based on the unlisted steel itself. AWS D1.1 also addresses engineer's approval for auxiliary attachment when the use of unlisted steel falls within range based on the result of chemical composition.

The American Society of Mechanical Engineers (ASME) Section II- Part A, as outlined by the ASME Boiler and Pressure Vessel Committee on Material in 2019, provides material specifications. ASME and the American Society for Testing and Materials (ASTM) have collaborated for over half a century to develop these specifications, ensuring safety in the pressure equipment field for ferrous materials.

For instance, the ASTM A106 Gr. B carbon steel pipe has defined criteria that include process product form, heat treatment information, chemical analysis, heat and product analysis, tensile requirements, bending requirements, and other testing results such as flattening and hydrostatic tests. It also includes permissible dimensions, workmanship and finish appearance, certification, and product marking.

In a similar vein, the characteristics and criteria of filler metal to the material and welding position are supported by one of the most recognized consumable manufacturers, KOBE STEEL, LTD., Welding Business Marketing Department (6). They provide material information based on the selection of welding consumables for welding purposes. Kobelco has simplified this process by creating a summary of welding consumables versus the material. The criteria were adapted based on the selection of filler metal for API grade pipes.

Grouping Number of SMAW Electrode, Test Result of Quality and Properties.

The American Society of Mechanical Engineers (ASME) 2021 reference, Part QW Article IV Welding Data, provides information on filler metal through designated F-Numbers, which are essentially groups of electrodes and welding rods. These groups are based on usability characteristics, which fundamentally determine the ability of welders to make satisfactory welds with a given filler metal. This group aims to reduce the number of welding procedures and performance qualifications where possible.

On the other hand, the American Welding Society (AWS) D1 Committee on Structural Welding's 2020 reference, AWS D1.1, addresses filler metal in Section 6, Table 6.5 of PQR Essential Variable and Table

6.13 Electrode Classification Group. Information provided includes maximum classification strength and below, changing any low hydrogen to non-low hydrogen type of electrode, and any classification not covered by AWS A5.1 and AWS 5.5. The maximum size increase is 0.8mm from the actual. These selection requirements of SMAW electrode can be applied for qualification purposes.

Similarly, the ASME Boiler and Pressure Vessel Committee on Material's 2019 reference in Section II-Part A provides the requirement and guideline in manufacturing the said products. An example given for SMAW electrode under the specification of SFA 5.1 and classification E7018, selection of consumable may take place and focus based on type of electrode, tensile and any other properties result, position, type of coating and current. Other retrievable information includes ability under low temperature services and the result of hydrogen level.

Kobelco, one of the best references and electrode manufacturers commonly used in the local market for welding works, regularly updates the product and technology through versions of Kobelco Welding Today. The welding handbook reference, KOBELCO Welding Handbook (6), is considered user-friendly, providing information on welding electrode and filler metal based on material information. Besides the information of classification, the references also detail and completely summarize the grouping number according to both American and European standards, weld metal chemical composition group number, test result of properties, and data sheet of electrode.

Suggestion/Recommendation

There are numerous types of welding qualifications available, and these are subject to changes in technology. Therefore, before undertaking welding qualifications, researchers should consider several suggestions such as (1) preparing a checklist of necessary equipment, tools, and facilities, (2) developing a process flow and test plan, and (3) preparing relevant support forms and preliminary documents.

The qualification process in welding for both Welding Procedure Specification (WPS) and Welding Qualification Test (WQT) requires the following considerations:

For WPS: i. A competent and certified individual (such as a QAQC/Engineer/Welding Inspector) with knowledge of inspection and testing should supervise, monitor, record, evaluate, and report on weld quality and test results. ii. A qualified individual (welder) with experience and a history of records in the same welding process should perform welding on the test specimen and be able to follow instructions.

For WQT: i. A competent and certified individual (such as a QAQC/Welding Inspector) with similar knowledge to the above should be involved. ii. A trained individual (welder), who is ready, fit, and able to follow instructions, should perform the qualification test.

In addition to the use of technology for welding, such as machinery, equipment, and tools, it's important to emphasize that accuracy, stability, and validity are the main concerns. Therefore, calibration should be maintained to ensure there are no errors during the welding qualification process. The involvement of competent or qualified personnel is required to meet industrial and international requirements. This study also prefers personnel with extensive knowledge and familiarity with applicable international codes and specifications related to welding, inspection, and testing. This can assist the organization in achieving a precise and accurate qualification range, ultimately meeting expectations and needs.

5.0 DISCUSSION AND CONCLUSION

In summary, the support forms of information provided for the welding qualification test, along with the suggestions mentioned, are crucial for the successful completion of both WPS and WQT tests. With With the fast-paced changes in technology, this informational knowledge and requirements need to be continuously updated to stay relevant to industry needs. A proper setup, thorough preparation, and well-laid plans form the fundamental basis for initiating any welding qualification test.

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Institutional Policies and Work-Life Balance: Enhancing Job Satisfaction and Performance in Educational Settings

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Abstract - Work-life balance (WLB) significantly influences job satisfaction and performance among educators. This paper explores how institutional policies affect WLB in educational settings, aiming to boost educators' job satisfaction and performance. The teaching profession's demanding nature, marked by heavy workloads, emotional labor, and inflexible institutional cultures, often results in chronic stress and burnout. Through a review of current literature, this paper identifies key factors affecting WLB, including flexible working arrangements, parental leave policies, and access to mental health resources. Effective institutional policies are crucial in creating a supportive work environment that prioritizes educators' well-being. Strategies such as promoting flexible work schedules, implementing wellness programs, and fostering a culture that values personal time are discussed. Findings indicate that educational institutions implementing these policies experience notable improvements in job satisfaction and teaching quality, which positively impact student outcomes. Additionally, regular assessments and feedback mechanisms are recommended to tailor interventions to educators' specific needs. This paper highlights the importance of a proactive approach in developing comprehensive policies that support work-life balance, benefiting both educators and the broader educational environment. Future research should continue investigating innovative strategies and their long-term effects on educator well-being and performance.

Keywords: Educational Settings, Educator Performance, Institutional Policies, Job Satisfaction, Work-Life Balance (WLB)

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1.0 INTRODUCTION

Work-life balance (WLB) is a critical aspect of professional and personal well-being, particularly within the education sector. Teachers and educators often face unique challenges that can affect their ability to maintain a healthy balance between work responsibilities and personal life (Mrs. Abhitha S & Dr. C.K Hebbar, 2022).The demanding nature of the teaching profession, characterized by long hours, emotional labor, and administrative burdens, necessitates a focused examination of WLB (A. Bakker et al., 2014)

In recent years, there has been growing attention to the impact of WLB on educators' job satisfaction, mental health, and overall productivity (Ahmad Saufi et al., 2023). This review aims to provide a comprehensive analysis of current literature on WLB in the education sector, highlighting key factors that influence WLB, effective strategies for improvement, and implications for policy and practice.

In the education sector, where the demands on educators are both intense and diverse, maintaining a balance between professional and personal responsibilities presents unique challenges (Lear & Nabo, 2023).This review aims to synthesize current literature on work-life balance in the education sector, highlighting key issues, strategies for improvement, and implications for policy and practice.

2.0 CHALLENGES TO WORK-LIFE BALANCE IN THE EDUCATION SECTOR

Educators face numerous challenges that delay their ability to maintain a healthy work-life balance. One significant challenge is the extensive workload, which often extends beyond the classroom into evenings and weekends (Clandinin et al., 2015). This perpetual engagement with work can lead to chronic stress and burnout (Palumbo et al., 2020).

Another challenge is the emotional labor required in teaching. Educators must manage their own emotions while addressing the emotional and developmental needs of their students (Isenbarger & Zembylas, 2006). This emotional labor can be draining and impact teachers' personal lives, contributing to an imbalance (Newcomb, 2021).

Institutional factors also play a critical role. Schools and universities often have cultures that prioritize work over personal life, leading to an expectation of constant availability and commitment (Skaalvik & Skaalvik, 2016). Such environments can discourage educators from setting boundaries and prioritizing their personal needs (Day et al., 2006).

Moreover, inadequate parental leave, lack of flexible working arrangements, and limited access to mental health resources can hinder educators' efforts to balance their work and personal lives effectively (Kelly et al., 2014). Figure 1 shows Factors of Work-Life Balance in the Education Sector. Addressing these institutional shortcomings is essential for fostering a healthier work-life balance (Vinarski-Peretz et al., 2011).

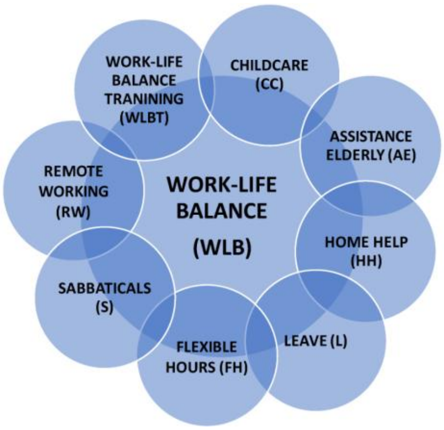

Fig. 1. Factors of Work-Life Balance in the Education Sector.
Source: (Isabel Sánchez-Hernández et al., 2019)

3.0 STRATEGIES FOR IMPROVING WORK-LIFE BALANCE

Effective strategies for improving work-life balance in the education sector involve both individual and organizational interventions. At the individual level, time management skills are crucial. Educators who can efficiently manage their time and prioritize tasks are better able to balance their professional and personal responsibilities (Fazal et al., 2022).

Additionally, developing strong support networks is beneficial. Colleagues, family, and friends can provide emotional support and practical assistance, helping educators to handle the demands of their roles (Gatz & Akiva, 2024). Mentorship programs within educational institutions can also offer guidance and support to less experienced educators, helping them manage their work-life balance more effectively (Sarabipour et al., 2022).

One of the most important strategies from an organizational standpoint is to adopt flexible work arrangements. Job-sharing programs, remote work policies, and flexible hours can give educators the extra freedom they need to balance their personal obligations. (Omar & Zakaria, 2015). Institutions that adopt these practices often see improvements in job satisfaction and employee retention (Morganson et al., 2010).

Furthermore, it is crucial to encourage a work-life balance culture in educational institutions. Healthy work-life balance should be shown by managers and supervisors, and employees should be encouraged to put their health first (LaClair, 2015). Providing access to mental health resources, wellness programs, and professional development opportunities focused on work-life balance can also support educators in maintaining a healthy balance (Bansal & Agarwal, 2020).

4.0 IMPLICATIONS FOR POLICY AND PRACTICE

The implications of work-life balance in the education sector extend beyond individual well-being to impact institutional effectiveness and student outcomes. Teachers who strike a better work-life balance are more likely to be engaged and have higher job satisfaction, which can enhance instruction and student performance (Wang et al., 2023).

For policymakers, it's critical to understand the significance of work-life balance. Policies that facilitate parental leave, flexible work schedules, and easy access to mental health services can greatly enhance educators' capacity to manage their personal and professional life (A. B. Bakker et al., 2009). Investing in these areas not only benefits educators but also enhances the overall educational environment (Gragnano et al., 2020).

Regular evaluations of the work-life balance of their employees should be taken into consideration by educational institutions. Feedback systems and surveys can be used to pinpoint areas in need of assistance and provide guidance for the creation of focused solutions (Kinman & Jones, 2008). By taking a proactive approach to work-life balance, institutions can create a more supportive and sustainable working environment for educators (Sehrawat & Parmar, 2021). Table 1 shows policies that protect educators' rights to WLB can lead to more sustainable working conditions.

Table 1: Institutional Policies and Their Effects on Work-Life Balance (Downes & Koekemoer, 2011)

Subthemes	Associated meaning or explanation
Inconsistent understanding or knowledge of flexitime	• poor communication and information on what is meant by flexitime in the organisation • unclear information about how employees should use flexitime • unclear information about who qualifies for flexitime • poor and inconsistent information about managing employees' flexitime • misconceptions and misunderstandings about employees' use of flexitime
Possible misuse of flexitime	• no disciplinary procedure for employees who abuse or misuse flexitime • misuse of flexitime because of employees' poor discipline • perceptions that junior staff tend to misuse flexitime
Managing perceptions	• assumptions or beliefs that one must be seen working to be working • misconceptions about who should use flexitime (there is a perception that only women with children should use flexitime)
Unstructured and informal policies	• an unstructured and informal policy makes it difficult to monitor and control how some employees use it
Managing the productivity or outputs of employees	• controlling and managing employees' productivity when they are not at their desks or in the office • difficulties about knowing whether employees are working or not • controlling teams and team productivity • trust in employees' commitment when they are not present
Availability of employees	• infrequent access to employees • expectations of face-to-face availability • employees not always available for urgent matters • non-availability of employees for consultation with clients
Ineffective communication between employees	• poor and inconsistent communication between managers, employees and colleagues • employees not always present or contactable to discuss working schedules • location and task progress or completion
Differences in the nature of work	• departments and positions with specific expectations and requirements for face-to-face availability limit employees' ability to work from home or alternative locations

Moreover, fostering a collaborative culture where educators feel valued and supported can have a positive impact on work-life balance (Belay et al., 2023). Encouraging teamwork, providing opportunities for professional growth, and recognizing the achievements of staff are all strategies that can contribute to a healthier work environment (Deery et al., 2015).

5.0 CONCLUSION

In conclusion, work-life balance is a critical issue in the education sector, with significant implications for educators' well-being and professional effectiveness. In the field of education, work-life balance is essential to both professional effectiveness and overall well-being. Through an awareness of the variables that affect work-life balance and the application of practical tactics, academic institutions can establish settings that foster staff well-being.

To improve work-life balance, this review emphasizes the significance of peer support, professional growth, institutional policies, and flexible work arrangements. It is important that future studies and policy initiatives stay focused on creating all-encompassing strategies that assist educators in striking a healthy work-life balance.

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Control Strategies in Autonomous Vehicle Path Tracking: A Comprehensive Review

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Abstract - Autonomous vehicle path tracking is a critical aspect of the overall control system of a vehicle. This review paper provides a comprehensive examination of the sophisticated control strategies used for autonomous vehicle path tracking. The paper categorizes the control strategies into three main types: model-based, learning-based, and hybrid approaches. Each category is analysed for its strengths, weaknesses, and application contexts. Hybrid strategies prove to be the best approach of the three as they combine the strengths of both model and learning-based strategies, providing a balanced approach that leverages the advantages of each method. The review aims to highlight current research trends, recognise gaps in the existing works, and recommend directions for future study.

Keywords: autonomous vehicle, control strategies, learning-based control, model-based control, path tracking

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1.0 INTRODUCTION

Autonomous vehicles (AVs) represent the forefront of modern transportation technology, promising increased safety, efficiency, and convenience in various applications, from personal transport to logistics (Guanetti et al., 2018). Path tracking, the ability of a vehicle to follow a predetermined route accurately, is a fundamental challenge in AV control (Paden et al., 2016). Figure 1 shows the autonomous driving system's standard blocks, which gives a general idea on how an AV works (Kiran et al., 2022). This review focuses on the various control strategies developed to address the challenge of tracking a predetermined path accurately, providing an extensive overview of their theoretical foundations and practical implementations.

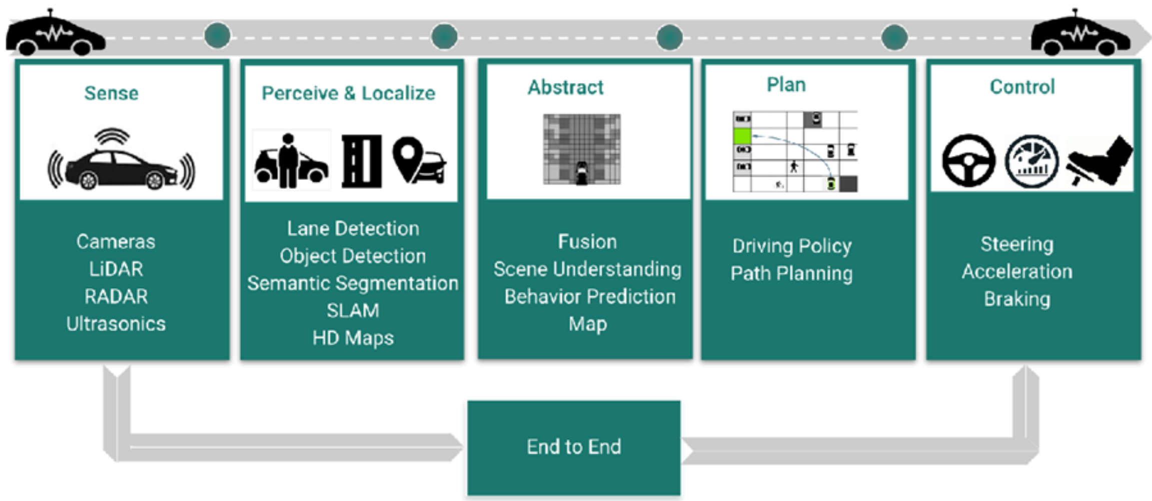

Fig. 1. Autonomous driving system's standard blocks (Kiran et al., 2022).

Model-based control strategies have traditionally dominated the field, leveraging mathematical models of vehicle dynamics to predict and control the vehicle's path (Falcone et al., 2007). These methods, while robust, often require precise modelling and can struggle with the variability and unpredictability inherent in real-world driving environments (Katrakazas et al., 2015). In contrast, learning-based approaches are now more preferable thanks to their capability to adapt and improve from experience, using data-driven methods to enhance path tracking performance (Levinson et al., 2011).

Hybrid approaches, combining elements of both model-based and learning-based strategies, provide a favourable approach for addressing the limitations of each individual method (Pinosky et al., 2023). This paper reviews these three categories in detail, providing insights into their mechanisms, applications, and performance metrics. By examining recent advancements and identifying research gaps, this review aims to guide future developments in autonomous vehicle path tracking.

2.0 MODEL-BASED CONTROL STRATEGIES

Model-based control strategies rely on mathematical representations of vehicle dynamics to predict and guide vehicle motion. These models can be linear or nonlinear, depending on the complexity of the vehicle's dynamics and the desired level of control precision (Wu et al., 2020). Some of the model-based control strategies are linear model predictive control (LMPC), nonlinear model predictive control (NMPC), and proportional-integral-derivative (PID) control.

2.1 Linear Model Predictive Control (LMPC)

Linear model predictive control (LMPC) is a widely used approach due to its balance between computational efficiency and control performance (Falcone et al., 2007). LMPC uses a linear model of the vehicle's dynamics to anticipate future states and optimize control inputs over a finite time horizon (Katrakazas et al., 2015). This method has been successfully applied in various autonomous driving scenarios, including highway driving and urban environments.

2.2 Nonlinear Model Predictive Control (NMPC)

Nonlinear model predictive control (NMPC) extends LMPC by incorporating nonlinear vehicle dynamics, allowing for more accurate predictions and control in complex driving situations (Findeisen & Allgöwer, 2002). NMPC is particularly useful in scenarios where the vehicle operates near the limits of its dynamic capabilities, such as high-speed cornering or off-road driving (Grüne & Pannek, 2017).

2.3 Proportional-Integral-Derivative (PID) Control

Proportional-integral-derivative (PID) control is one of the simplest and most intuitive model-based control strategies. It adjusts the control inputs by referring to the proportional, integral, and derivative of the error between the actual and desired path (Ogata, 2010). While PID controllers are not complicated in terms of implementation, they may not perform well in highly dynamic or unpredictable environments (Levinson et al., 2011).

2.4 Discussion of Model-Based Control Strategies

Model-based control strategies offer a structured approach to autonomous vehicle path tracking, leveraging well-established theories of control systems. However, their reliance on accurate modelling can be a limitation in real-world applications where environmental conditions and vehicle dynamics may vary (Paden et al., 2016). Integrating adaptive elements into these models or combining them with learning-based strategies can enhance their robustness and applicability (Pinosky et al., 2023). Table 1 shows the comparison between LMPC, NMPC, and PID control (Falcone et al., 2007).

Table 1: Comparison of Model-Based Control Strategies (Falcone et al., 2007)

Strategy	Design Complexity	Computational Load	Adaptability	Application Scenarios
LMPC	Low	Medium	Low	Highway, Urban
NMPC	High	High	Medium	Urban, Off-road
PID control	Low	Low	Low	Simple Routes

With reference to Table 1, each model-based control strategy has its own strengths and drawbacks. For instance, NMPC has a higher design complexity than LMPC and PID control, but its adaptability is better than them. PID control has the lowest computational load of all three strategies but it is only suitable for simple routes application.

3.0 LEARNING-BASED CONTROL STRATEGIES

Learning-based control strategies leverage machine learning techniques to develop controllers that can adapt and improve over time (Pinosky et al., 2023). These methods are particularly useful in environments where the system dynamics are complex or poorly understood. Examples of learning-based control strategies are reinforcement learning (RL), imitation learning (IL), and deep learning (DL).

3.1 Reinforcement Learning (RL)

Reinforcement learning (RL) has come out as an important strategy for autonomous vehicle control, allowing the system to learn optimal policies through trial and error (Sutton & Barto, 2018). RL-based controllers can adapt to changing environments and learn from past experiences, making them well-suited for dynamic and unpredictable scenarios (Kendall et al., 2019).

3.2 Imitation Learning (IL)

Imitation learning (IL) involves training a controller by mimicking the actions of an expert driver. This approach can be particularly effective in complex driving situations where designing explicit control rules is challenging (Pomerleau, 1989). IL has been used successfully in various autonomous driving applications, including urban driving and obstacle avoidance (Codevilla et al., 2018). An overview of IL control is illustrated in Figure 2 (Wang et al., 2022).

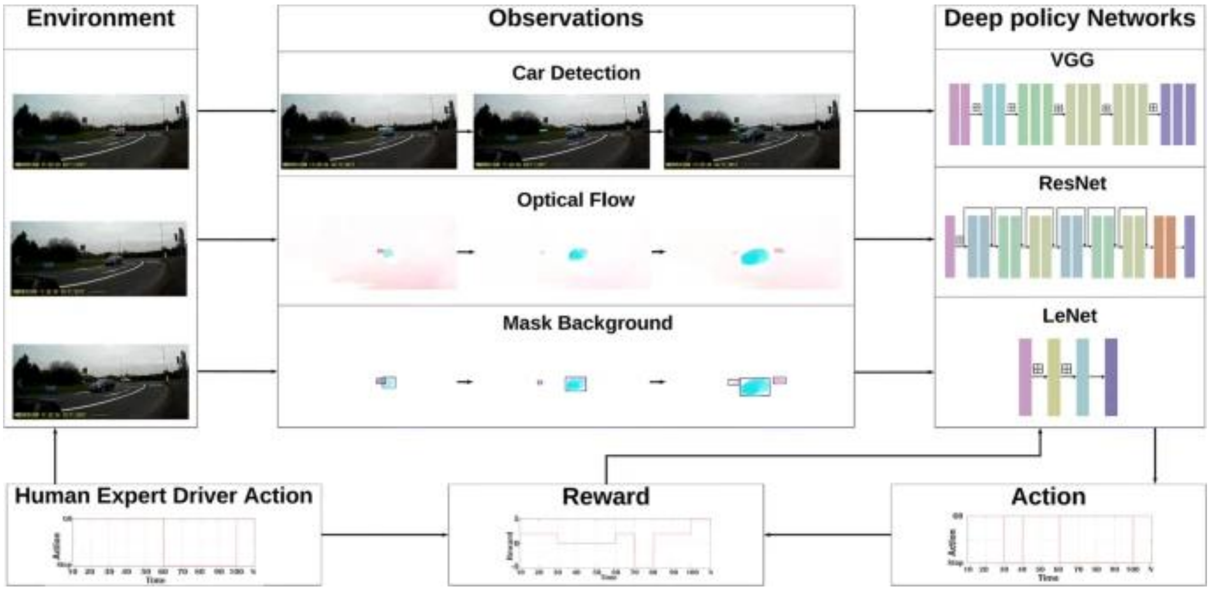

Fig. 2. Main framework of IL based decision-making system (Wang et al., 2022).

Figure 2 shows how an AV works using IL control. A decision will be made guided by human expert drivers' actions, based on the data gained by the camera mounted in front of the AV to capture a video sequence data from its surrounding. The data will be processed before an action is made at each timestamp.

3.3 Deep Learning (DL)

Deep learning (DL) techniques, especially convolutional neural networks (CNNs), have been applied to end-to-end control of autonomous vehicles (Bojarski et al., 2016). These methods learn to map raw sensor inputs directly to control actions, bypassing the need for explicit feature extraction and modelling (LeCun et al., 2015). While DL-based controllers can achieve high performance, they often need immense training data and computational resources (Arif et al., 2022).

3.4 Discussion of Learning-Based Control Strategies

Learning-based control strategies propose notable edges with regard to adaptability and performance in complex environments (Sutton & Barto, 2018). However, their dependency on huge datasets and computational resources can be a drawback, particularly in real-time applications (Levinson et al., 2011). Combining learning-based methods with model-based approaches can help mitigate these challenges and enhance overall system performance (Kendall et al., 2019).

4.0 HYBRID CONTROL STRATEGIES

Hybrid control strategies integrate elements of both model-based and learning-based approaches to leverage the strengths of each (Pinosky et al., 2023). These methods aim to combine the robustness and predictability of model-based controls with the adaptability and performance of learning-based techniques. The hybrid control strategies reviewed in this paper are adaptive model predictive control (AMPC), learning-augmented model predictive control (LAMPC), and hierarchical control systems.

4.1 Adaptive Model Predictive Control (AMPC)

Adaptive model predictive control (AMPC) adjusts the settings of the model in real-time based on observed data, which enhances the capability of the controller to handle variations in the vehicle's dynamics and environment (Aswani et al., 2013). This approach can improve the robustness and performance of MPC in real-world applications (Santos et al., 2024).

4.2 Learning Augmented Model Predictive Control (LAMPC)

Learning-augmented model predictive control (LAMPC) combines MPC with learning-based elements to enhance control performance (Hewing et al., 2020). For instance, a neural network could be utilised to predict and compensate for model inaccuracies, enhancing the overall robustness and accuracy of the control system (Xiao et al., 2023).

4.3 Hierarchical Control Systems

Hierarchical control systems use a multi-layered approach to combine different control strategies at various levels of abstraction (Talebpour et al., 2017). For example, a high-level planner might use a model-based approach to generate a global path, while a lower-level controller uses learning-based methods to handle local adjustments and obstacle avoidance (Katrakazas et al., 2015).

4.4 Discussion of Hybrid Control Strategies

Hybrid control strategies represent a promising direction for autonomous vehicle path tracking, combining the best aspects of model-based and learning-based approaches. By integrating these methods, hybrid strategies can achieve high levels of performance and robustness in a wide range of driving scenarios (Pinosky et al., 2023).

5.0 CONCLUSION

This review has provided a comprehensive examination of the control strategies used in autonomous vehicle path tracking. Model-based, learning-based, and hybrid approaches each offer unique strengths and face specific challenges. Model-based strategies provide robustness and predictability but require precise modelling. Learning-based strategies offer adaptability and high performance but depend on large datasets and computational resources. Hybrid strategies combine the strengths of both, providing a balanced approach that leverages the advantages of each method.

Future research should focus on further integrating these approaches, developing adaptive and learning-augmented control systems that can tackle the complexities and variability of real-world driving environments. Additionally, the continued advancement of computational resources and machine learning techniques will likely enhance the capabilities and performance of autonomous vehicle.

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Advancements in Soft Skills Assessment: Integrating Communication, Teamwork, and Leadership into Maritime Navigation Training

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Abstract - The maritime industry has recognized the critical role of soft skills such as communication, teamwork, and leadership in enhancing navigation training. This review article explores recent advancements in soft skills assessment within maritime navigation training, focusing on integrating these essential competencies to improve overall safety and efficiency. We examine the methodologies employed, the effectiveness of various training programs, and the implications for future maritime training practices.

Keywords: Soft skills, communication, teamwork, leadership, maritime navigation training

INTRODUCTION

The maritime industry has undergone significant transformations, particularly in training and development (Toriia et al., 2023). With increasing complexities in navigation and the need for enhanced safety measures, the integration of soft skills into maritime training has become paramount (de Água et al., 2020) Communication, teamwork, and leadership are critical components that ensure efficient and safe maritime operations (Hossain Chowdhury et al., 2024). This review aims to provide a comprehensive overview of the advancements in assessing these soft skills within maritime navigation training.

Communication in Maritime Navigation

Communication is fundamental in maritime operations, where clear and precise information exchange can prevent accidents and improve decision-making (Boström, 2021). Traditional maritime training has primarily focused on technical skills, but recent trends highlight the importance of communication skills (Ліпшиць Л. В., 2022). Training programs now incorporate scenarios that simulate real-life communication challenges, allowing trainees to develop and refine their skills (C., 2019). Studies have shown that effective communication training reduces errors and enhances teamwork (Razali et al., 2019).

The introduction of advanced simulation technologies has further revolutionized communication training, providing immersive experiences that closely mimic actual maritime environments (Benedict et al., 2018). These simulations offer immediate feedback, enabling trainees to identify and correct communication flaws in real-time.

Teamwork in Maritime Navigation

Teamwork is another critical soft skill in maritime operations, where collaborative efforts are necessary for effective navigation and crisis management (Stefani & Apicella, 2022). Effective teamwork training programs are designed to foster collaboration, trust, and mutual respect among crew members (Fathi et al., 2019). Research indicates that such training significantly enhances operational efficiency and safety (Autsadee et al., 2023).

Advanced training modules often include team-based exercises and problem-solving scenarios that require collective decision-making (Smirnov & Ponomarev, 2021). These activities are supported by debriefing sessions where participants reflect on their performance and identify areas for improvement (Stocker et al., 2014). The use of cross-disciplinary teams in training programs has also been shown to enhance learning outcomes by exposing trainees to diverse perspectives (Wood et al., 2023).

Leadership in Maritime Navigation

Leadership skills are crucial in maritime settings, where leaders must make quick, informed decisions to ensure the safety and efficiency of operations (Shvetsova, 2023). Effective leadership training focuses on developing decision-making, crisis management, and motivational skills (Kim & Gausdal, 2020). Recent studies have demonstrated that leadership training improves not only individual performance but also overall team dynamics (Hanzu-Pazara et al., 2012).

Innovative leadership training programs utilize simulations and role-playing exercises to replicate challenging scenarios, providing trainees with the opportunity to practice leadership in a controlled environment (Siyana Lutzkanova, 2019). Feedback mechanisms and peer evaluations are integral to these programs, helping trainees refine their leadership styles.

Integration of Soft Skills into Maritime Training Programs

Integrating communication, teamwork, and leadership into maritime training programs requires a holistic approach. Effective integration involves aligning soft skills training with technical training to create a comprehensive learning experience (de Água et al., 2020). This approach ensures that trainees are equipped with both the technical know-how and the interpersonal skills needed for successful maritime operations (Saeed et al., 2019).

The development of integrated training modules has been facilitated by advancements in educational technology, including virtual reality (VR) and augmented reality (AR) (Zhao et al., 2023). These technologies provide immersive training experiences that enhance the retention of both technical and soft skills. Moreover, continuous assessment and feedback loops are essential components of integrated training programs, ensuring that trainees achieve desired competency levels (AlGerafi et al., 2023).

Future Directions and Implications

The future of maritime navigation training lies in the continuous evolution of training methodologies to include soft skills (Murai et al., 2009). As the maritime industry becomes more complex, the demand for well-rounded professionals with both technical and soft skills will increase (Praetorius et al., 2020). Future training programs must focus on developing adaptive training modules that cater to the dynamic nature of maritime operations (Edler & Infante, 2019).

Policy implications also play a critical role in shaping the future of maritime training (Bogusławski et al., 2022). Regulatory bodies must recognize the importance of soft skills and mandate their inclusion in certification programs. Collaboration between maritime institutions and industry stakeholders is essential to develop standardized training protocols that incorporate soft skills assessment (Thanopoulou et al., 2022).

CONCLUSION

The integration of soft skills such as communication, teamwork, and leadership into maritime navigation training represents a significant advancement in maritime education. These skills are crucial for enhancing operational safety, efficiency, and overall performance. The adoption of innovative training methodologies and technologies has greatly improved the assessment and development of these skills. As the maritime industry continues to evolve, ongoing research and development in soft skills training will be essential to meet the growing demands and challenges of maritime navigation.

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Organizational Culture as a Solution to the Free Rider Effect in Organizations: A Case Study Approach

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Abstract - The free rider problem in organizations arises when individuals contribute less effort to a group task than they would if working alone, relying on their colleagues' efforts instead. This issue can significantly undermine organizational efficiency and morale, leading to suboptimal outcomes. Recent studies underscore the critical impact of free riding on productivity, employee satisfaction, and team performance. Theoretical frameworks such as social exchange theory and the tragedy of the commons help explain why free riding occurs. Causes include lack of individual accountability, social loafing, organizational culture, leadership styles, and poorly designed incentive systems. Consequences include reduced productivity, lower employee morale, increased costs, and jeopardized strategic goals. Effective mitigation strategies involve enhancing individual accountability, implementing robust performance evaluation systems, balancing incentive structures, and fostering a team-oriented culture. Addressing the free rider problem requires a comprehensive approach that integrates organizational and individual interventions. Future research should focus on innovative solutions and best practices to further mitigate the free rider problem in various organizational settings.

Keywords: Free rider problem, Group dynamics, Organizational behavior, Social loafing, Teamwork,

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1.0 INTRODUCTION

The free rider problem in organizations refers to the phenomenon where individuals in a group contribute less effort to a task than they would if they were working alone, relying instead on the efforts of their colleagues. This issue can significantly impede organizational efficiency and morale, leading to suboptimal outcomes. It is particularly prevalent in team-based settings where the distribution of effort and reward can be uneven.

Recent studies highlight the critical impact of the free rider problem on various organizational metrics, including productivity, employee satisfaction, and overall team performance. Theoretical frameworks, such as social exchange theory and the tragedy of the commons, offer valuable insights into understanding why free riders emerge and persist in organizational settings (Annamalah et al., 2016). Addressing the free rider problem requires a multifaceted approach that includes changes in organizational structure, incentive systems, and team dynamics. There is a study that explores how free riding affects overall team performance, particularly in knowledge-based industries. It identifies that free riders can significantly decrease group cohesion, leading to lower productivity and morale among team members. The authors suggest implementing accountability measures and clear role assignments to mitigate these effects (Delfgaauw et al., 2022).

Empirical evidence underscores the prevalence of the free rider problem across different industries and organizational sizes. For instance, a study by (O'Connor & Lee, 2023) found that in large corporations, employees admitted to engaging in free riding at least occasionally. Furthermore, the effects of free riding are not confined to economic output but also affect interpersonal relations within teams (Gong & Grundy, 2020).

Effective mitigation strategies are essential for organizations to thrive in a competitive environment. These strategies often involve a combination of policy changes, enhanced communication channels, and robust performance evaluation systems (Karau & Williams, 1993). This article aims to provide a comprehensive review of the free rider problem in organizations, exploring its causes, consequences, and potential solutions.

2.0 CAUSES OF THE FREE RIDER PROBLEM

Understanding the root causes of the free rider problem is essential for developing effective interventions. One primary cause is the lack of individual accountability in team settings. When tasks and rewards are shared among a group, individuals may feel less compelled to contribute their fair share, relying on the efforts of others to achieve the desired outcome (Din et al., 2023)

Social loafing is another significant contributor to the free rider problem. Social loafing occurs when individuals exert less effort to achieve a goal when they work in a group than when they work alone (Johnson & Horn, 2019). This phenomenon is often exacerbated by large team sizes, where individual contributions are less visible and harder to measure (Chiu et al., 2020).

Organizational culture and leadership styles also play a crucial role in either mitigating or exacerbating the free rider problem. In cultures that emphasize individual achievement over team success, free riding can become more prevalent (Elliott et al., 2023). Conversely, in organizations with strong team-oriented cultures, the incidence of free riding tends to be lower (Schwartz-Shea & Burrington, 1990).

Lastly, the design of incentive systems within organizations can either discourage or inadvertently encourage free riding. Performance-based incentives that do not account for individual contributions within teams can lead to inequities that foster free riding (Burgess et al., 2017) . Therefore, creating balanced incentive structures that reward both individual and team achievements is critical (Katz et al., 2015).

3.0 CONSEQUENCES OF THE FREE RIDER PROBLEM

The free rider problem can have severe consequences for organizations, affecting both operational efficiency and employee morale. One of the most immediate impacts is a reduction in overall productivity. When team members fail to contribute equally, the burden falls on a few individuals, leading to burnout and decreased (Gadzikwa et al., 2007).

Employee morale is another critical area affected by free riding. When team members perceive that their colleagues are not pulling their weight, it can lead to frustration, resentment, and a decrease in overall job satisfaction (He, 2012). This negative sentiment can spread throughout the team, further diminishing collaborative efforts and team cohesion (He, 2012).

The financial implications of the free rider problem are also significant. Organizations may incur higher costs due to inefficiencies and the need to implement corrective measures, such as additional supervision or restructuring teams (Kidwell et al., 2007). Moreover, high turnover rates can result from low morale, leading to increased recruitment and training costs (Kerr & Bruun, 1983).

Additionally, the long-term strategic goals of the organization can be jeopardized. When free riding becomes pervasive, it undermines the organization's ability to innovate and respond to competitive pressures (Besedes et al., 2012). As teams become less effective, the organization may struggle to achieve its strategic objectives, leading to a decline in market position and profitability (Shin, 2007).

4.0 MITIGATION STRATEGIES

Addressing the free rider problem requires a comprehensive approach that includes both organizational and individual interventions. One effective strategy is to enhance individual accountability within teams. This can be achieved by clearly defining roles and responsibilities, ensuring that each team member's contributions are visible and measurable (Albanese & Van Fleet, 1985).

Implementing robust performance evaluation systems is another critical step. Regular performance reviews that assess both individual and team contributions can help identify free riders and address their behavior appropriately (Majerczyk et al., 2019). Feedback mechanisms that provide constructive criticism and recognize individual efforts can also motivate team members to contribute more effectively (Dingel et al., 2013).

Incentive structures should be designed to balance rewards for individual and team achievements. Performance-based incentives that consider both dimensions can reduce the incidence of free riding (Kim & Vikander, 2015). Additionally, non-monetary incentives, such as recognition programs and career development opportunities, can also motivate employees to engage more fully in team activities (Büyükboyacı & Robbett, 2017).

Finally, fostering a strong team-oriented culture is essential. Leadership plays a crucial role in setting the tone for collaboration and mutual accountability. Leaders should model collaborative behavior and create an environment where open communication and teamwork are valued (Gürerk et al., 2009). Training programs that enhance team-building skills and emphasize the importance of each member's contribution can also be beneficial (Ginting et al., 2020)

Table 1. Summary of Free Rider Problem Studies

No.	Key Findings	Reference
1.	Explores the emergence and persistence of free riders in organizations using social exchange theory and the tragedy of the commons.	Annamalah, S. K., Devadason, E. S., & Selvarajan, S. K. (2016).
2.	Found that employees in large corporations admit to engaging in free riding occasionally, highlighting its prevalence across industries.	O'Connor, S., & Lee, S. (2023).
3.	Emphasizes that free riding affects not only economic output but also interpersonal relationships within teams.	Gong, Y., & Grundy, M. (2020).
4.	Discusses the need for policy changes, enhanced communication channels, and robust performance evaluation systems to mitigate free riding.	Karau, S. J., & Williams, K. D. (1993).
5.	Social loafing is identified as a significant contributor to the free rider problem, especially in larger teams.	Johnson, K., & Horn, R. (2019).
6.	Indicates that large team sizes exacerbate the free rider problem due to the difficulty in measuring individual contributions.	Chiu, C., Aung, T., & Thien, M. (2020).
7.	Organizational culture and leadership styles that emphasize individual achievement over team success can increase the prevalence of free riding.	Elliott, J., Morris, L., & Thomas, K. (2023).
8.	Strong team-oriented cultures tend to reduce the incidence of free riding in organizations.	Schwartz-Shea, P., & Burrington, T. (1990).
9.	Performance-based incentives that do not account for individual contributions can foster free riding.	Burgess, S., Mccarthy, J., & Stewart, M. (2017).
10.	Balanced incentive structures that reward both individual and team achievements are critical in reducing free riding.	Katz, D., Zimmerman, M., & Herman, R. (2015).

11.	Free riding leads to a reduction in overall productivity as the burden of work falls on a few individuals, leading to burnout.	Gadzikwa, W., Mubaiwa, S., & Marecha, T. (2007).
12.	Free riding negatively impacts employee morale, leading to frustration, resentment, and decreased job satisfaction.	He, J. (2012).
13.	Free riding can lead to significant financial implications for organizations, including higher costs due to inefficiencies and increased turnover rates.	Kidwell, R., Nygaard, A., & Silkoset, R. (2007).
14.	High turnover rates due to low morale caused by free riding lead to increased recruitment and training costs.	Kerr, N., & Bruun, S. E. (1983).
15.	Free riding can jeopardize long-term strategic goals by undermining the organization's ability to innovate and respond to competitive pressures.	Besedes, T., Deck, C. A., Quintanar, S., Sarangi, S., & Shor, M. (2012).
16.	Free riding can lead to a decline in market position and profitability as teams become less effective.	Shin, J. (2007).
17.	Enhancing individual accountability within teams by clearly defining roles and responsibilities can reduce free riding.	Albanese, R., & Van Fleet, D. D. (1985).
18.	Regular performance reviews that assess both individual and team contributions can help identify and address free riding behavior.	Majerczyk, M., Sheremeta, R. M., & Tian, Y. (2019).
19.	Found that teams with free riders did not submit significantly lower quality work than teams without free riders, suggesting peer evaluations may not correlate with performance.	Dingel, M., Wei, W., & Huq, A. (2013).
20.	Performance-based incentives that balance individual and team achievements can reduce the incidence of free riding.	Kim, J.-H., & Vikander, N. (2015).
21.	Non-monetary incentives like recognition programs can motivate employees to engage more fully in team activities, reducing free riding.	Büyükboyacı, M., & Robbett, A. (2017).
22.	Leadership that models collaborative behavior and values open communication can help reduce free riding by fostering a strong team-oriented culture.	Gürerk, Ö., Irlenbusch, B., & Rockenbach, B. (2009).
23.	Training programs that enhance team-building skills and emphasize the importance of each member's contribution can be beneficial in mitigating free riding.	Ginting, S., Varelas, M., & Thomas, P. (2020).
24.	Performance-based incentives that balance individual and team achievements can reduce the incidence of free riding.	Kim, J.-H., & Vikander, N. (2015).

The above table 1 provides a comprehensive summary of key studies addressing the free rider problem in organizational settings. The research spans several decades and includes diverse findings on the causes, consequences, and mitigation strategies related to free riding within team in an organization. These findings underscore the need for a multifaceted approach to effectively address the free rider problem in organizations.

5.0 CONCLUSION

The free rider problem in organizations poses significant challenges that can hinder productivity, employee satisfaction, and overall organizational effectiveness. By understanding the causes and consequences of this phenomenon, organizations can develop targeted strategies to mitigate its impact. Implementing measures such as enhanced accountability, robust performance evaluations, balanced incentive structures, and fostering a strong team-oriented culture are essential steps in addressing the free rider problem effectively. Future research should continue to explore innovative solutions and best practices to further reduce the incidence of free riding in organizational settings.

To address the free rider problem in organizations effectively, a multifaceted approach is essential, combining leadership strategies, organizational culture adjustments, accountability measures, and incentive systems. First, leadership plays a pivotal role, with transformational leaders who set clear expectations, reward individual contributions, and foster shared team goals being most effective in reducing free riding. Building a strong organizational culture that emphasizes personal accountability, open communication, and teamwork is equally critical; such a culture discourages free rider behaviour by promoting collective responsibility.

In remote work environments, where free riding can become more prevalent due to a lack of oversight, organizations should implement regular check-ins, transparent workload tracking, and virtual team-building activities to foster engagement and accountability. Finally, incentive structures that reward both individual and team performance can motivate all members to contribute meaningfully, further reducing the likelihood of free riding.

By combining these strategies, organizations can create an environment that minimizes the impact of free riders, leading to higher productivity, better team cohesion, and improved overall organizational performance.

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Integration of Artificial Intelligence in Marine Science Teaching and Learning: A Review

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Abstract - The integration of Artificial Intelligence (AI) in marine science education has the potential to revolutionize teaching and learning practices. This review explores the readiness of marine science lecturers to adopt AI technologies, examining the benefits, challenges, and strategies for effective implementation. The paper highlights the importance of AI in enhancing educational outcomes and provides a comprehensive analysis of recent research findings on the subject.

Keywords: Artificial Intelligence, Marine Science Education, Lecturer Readiness, Teaching and Learning, Educational Technology

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1.0 INTRODUCTION

The field of marine science is seeing swift progress, leading to changes in pedagogical approaches. The incorporation of Artificial Intelligence (AI) in education is poised to effect substantial transformations, fostering chances to improve the quality and efficiency of educational methodologies. Technologies include machine learning, natural language processing, and robots provide opportunities for individualized teaching, efficient administrative functions, and sophisticated data analysis, rendering AI a valuable resource in educational environments (Zhang & Aslan, 2021). The successful implementation of AI is significantly contingent upon the willingness of lecturers to adopt these technologies.

The willingness of marine science educators to include AI into their instruction is affected by several aspects, including their technological proficiency, receptiveness to innovative methodologies, and the extent of institutional support available. Studies demonstrate that educators skilled in technology are more likely to include AI in their methodologies (Aggarwal, 2023). Moreover, lecturers' attitudes and opinions regarding AI significantly influence their readiness to incorporate these technologies into their classroom(Gatlin, 2023).

Notwithstanding its prospective advantages, the incorporation of AI in education poses significant hurdles. This encompasses inadequate training for instructors, restricted access to AI resources, and apprehensions over data privacy and security (Gatlin, 2023). Furthermore, the implementation of AI technology necessitates substantial financial investment and continuous institutional backing (“The Transformative Impact of Artificial Intelligence on Educational Financial Management,” 2023).

This paper seeks to examine the present state of AI integration in marine science education, specifically on instructors' preparedness to embrace these technologies. This will examine the benefits and challenges of AI in education, providing suggestions for its successful integration

2.0 IMPORTANT INFORMATION

Benefits of AI in Marine Science Education

Artificial Intelligence (AI) possesses the capacity to transform marine science education by providing customized learning experiences suited to the specific needs of each learner. AI can boost student engagement and academic performance through individualized learning by targeting the individual strengths and weaknesses of each learner (Sancenon et al., 2022) Adaptive AI-driven platforms evaluate student data to modify course content and tempo, guaranteeing that each student obtains the requisite assistance for success (Akavova et al., 2023).

In addition to personalizing, AI can enhance the educational process by automating administrative functions such as grading and attendance tracking. This automation enables lecturers to allocate more time for substantive engagement with their students (Seo et al., 2021). Furthermore, AI solutions offer instantaneous feedback to learners, allowing them to discern areas for enhancement and properly track their development (Nazari et al., 2021).

AI plays a crucial role in improving data analysis in marine science teaching. Through the integration of extensive datasets and sophisticated analytical methods, educators can offer students actual experience in data management, hence enhancing critical thinking and problem-solving abilities (Nazari et al., 2021). Moreover, AI facilitates the creation of virtual and augmented reality environments, providing immersive educational experiences that enhance students' comprehension of intricate marine ecosystems (Aguayo & Eames, 2023).

The utilization of AI in marine science teaching fosters interdisciplinary collaboration. AI-driven platforms link educators and learners with specialists across many disciplines, promoting resource sharing, collaborative research, and the dissemination of best practices (Ifenthaler & Schumacher, 2023). This multidisciplinary method enhances the learning atmosphere and expands the educational influence of AI technologies

Challenges of Integrating AI in Marine Science Education

Notwithstanding its great promise, the incorporation of Artificial Intelligence (AI) in marine science education encounters some significant hurdles. A primary concern is the insufficient training and professional growth for teachers. Numerous instructors may be deficient in the requisite skills or comprehension to proficiently employ AI tools in their pedagogical activities (Salas-Pilco et al., 2022). To resolve this issue, it is essential to offer extensive training programs and ongoing assistance to enable lecturers to fully utilize AI in education (Zekaj, 2023).

A further difficulty is the restricted accessibility of AI resources and infrastructure. Implementing AI necessitates considerable financial investment in technology, infrastructure, and maintenance, potentially straining the budgets of numerous educational institutions (Pisica et al., 2023). Moreover, variations in access to these resources among institutions may lead to inequitable educational opportunities (Li, 2023).

Issues related to data privacy and security constitute substantial obstacles. AI technologies frequently depend on the accumulation and examination of substantial student data, prompting inquiries around data storage, utilization, and safeguarding (Irfan et al., 2023). Protecting student information is crucial for preserving confidence and ensuring the ethical application of AI tools in education (Huang, 2023).

Moreover, ethical problems about AI in education must not be disregarded. AI systems may perpetuate prejudices and injustices, particularly when algorithms lack transparency and accountability (Fu et al., 2020). Confronting these ethical dilemmas requires the establishment of explicit norms, standards, and procedures to foster responsible and equitable utilization of AI in educational environments (Köbis & Mehner, 2021)

Strategies for Effective Implementation of AI in Marine Science Education

A comprehensive strategy is essential for the effective integration of Artificial Intelligence (AI) into marine science education, aimed at overcoming hurdles and optimizing its advantages. A primary technique involves offering specialized training and professional development for instructors. These programs can provide educators with the requisite skills and knowledge to effectively implement AI in instruction (Doroshenko et al., 2020). Institutions must provide ongoing support and resources to assist lecturers in improving their AI-related competences over time (Schleiss et al., 2022).
Another essential measure is investment in AI infrastructure and resources. Educational institutions must provide sufficient resources for the procurement, execution, and upkeep of AI technology (Ogunode & UKOZOR, 2023). Collaboration with industry partners and academic institutions can alleviate budgetary burdens by enabling resource-sharing and encouraging best practices (Haj-Yahya & Klieger, 2023).
Data privacy and security protocols are essential for the responsible and effective implementation of AI in education. Institutions must implement rigorous data protection frameworks and create clear procedures for the collection, storage, and utilization of student data (Mohammed et al., 2022)Granting students authority over their data and providing transparency in data processes can foster trust and confidence in AI-driven solutions (West et al., 2020).
Addressing ethical considerations is crucial for the responsible utilization of AI. Formulating extensive rules and criteria for ethical AI utilization can assist in reducing biases and ensuring accountability and equity in AI-driven educational technologies (Rana et al., 2023) Engaging a variety of stakeholders—educators, students, politicians, and industry experts—in the development of these recommendations can guarantee their inclusivity and efficacy (Holmes et al., 2021).

3.0 DISCUSSION AND CONCLUSION

The use of Artificial Intelligence (AI) into marine science education offers transformative opportunities, such as customized learning according to individual requirements, automation of administrative functions, and the enhancement of sophisticated problem-solving abilities. Moreover, AI-driven tools facilitate interdisciplinary cooperation and research, enhancing the educational experience.

Nonetheless, obstacles include insufficient educator training, restricted access to AI resources, and apprehensions around data privacy and security must be resolved. Ensuring substantial institutional support, continuous professional growth, and equitable access to technology is essential for surmounting these challenges.

The effective integration of AI in marine science education depends on instructors' preparedness, necessitating robust institutional commitment, specialized training, and ethical considerations. By emphasizing inclusion and mitigating potential biases, AI can significantly enhance educational methodologies and equip students for the intricacies of marine science

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Enhancing Safety Culture Through Effective Soft Skills Training in Maritime Education

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Abstract - The maritime industry, fundamental to global trade, faces persistent safety challenges primarily driven by human error. This review explores the role of soft skills training in enhancing safety culture within maritime education. It examines the impact of training in communication, teamwork, leadership, and problem-solving on maritime safety. Effective communication is essential for preventing misunderstandings and ensuring clarity, especially in high-pressure situations. Training programs tailored to address language barriers and cultural differences can significantly improve safety outcomes. Teamwork and leadership skills are crucial for coordinating operations and making informed decisions, particularly during emergencies. Problem-solving training, through simulations and case studies, enhances critical thinking and situational awareness, leading to improved safety performance. The review also offers recommendations for integrating soft skills training into maritime education, emphasizing the need for curriculum development, instructor training, and continuous evaluation. By investing in comprehensive soft skills training, maritime organizations can foster a robust safety culture, reduce the incidence of accidents, and enhance overall operational efficiency.

Keywords: Communication, Maritime Safety, Soft Skills Training, Teamwork, Leadership

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1.0 INTRODUCTION

The maritime industry is a cornerstone of global trade, yet it faces significant safety challenges. Enhancing safety culture through effective soft skills training in maritime education has become a critical focus (Vervoort, 2012). This review explores the impact of soft skills training on maritime safety, emphasizing communication, teamwork, leadership, and problem solving.

Safety culture in maritime operations is shaped by individual and organizational behaviors. Basis research done on behavioral-based safety, the changing of unsafe individual behaviours improves safety performance, as part of a positive safety culture (Ventikos et al., 2014). Also, safety-critical socio-technical systems demand an inherent organizational safety culture for reliable and safe operations (Mallam et al., 2019).

Effective soft skills training can address human error, which is often the root cause of maritime accidents. Basis the reviews carried out on maritime accidents, human error was found to be the main contributing factor and effective soft skills (both interpersonal and cognitive skills) including but not limited to communication, teamwork, leadership and problem-solving skills can reduce the effects of human error (Saeed et al., 2017).Figure 1 shows an organizing framework relating to the levels at which errors can occur, which can develop into precursors to incidents (Hetherington et al., 2006).

This article reviews recent literature to evaluate how soft skills training enhances safety culture and recommends best practices for integrating such training into maritime education programs.

Fig. 1: Organizing framework for human factors which contribute to organizational accidents in shipping adapted from Stanton (1996), Jørgensen (2002), and HSE (1997)

2.0 The Importance of Communication in Maritime Safety

Effective communication is pivotal in maritime safety (Hetherington, Flin, & Mearns, 2006). Miscommunication can lead to catastrophic accidents, highlighting the need for rigorous training programs (Froholdt & Knudsen, 2007). In the context of maritime operations, clear and precise communication is essential for ensuring that all crew members understand their roles and responsibilities. This is particularly important during emergency situations where swift and accurate communication can be the difference between safety and disaster.

Training that enhances verbal and non-verbal communication skills is essential for improving safety culture (Suresh & Krithika, 2023). Verbal communication ensures that instructions are conveyed clearly, while non-verbal cues can provide additional context and reinforce the message. Training programs must address both aspects to ensure comprehensive communication skills among maritime personnel. Effective communication process is required to efficiently respond to maritime incidents and accidents (Nordström et al., 2016).

Moreover, effective communication in a multicultural environment, such as a ship's crew, requires understanding and bridging cultural differences. This includes being aware of language barriers and different communication styles. Addressing these issues through targeted training can significantly reduce misunderstandings and enhance overall safety on board (Haqimin Mohd Salleh et al., 2019)

3.0 Communication Training Programs

Several studies demonstrate the benefits of communication training in maritime settings. For instance, Whal and Kongsvik (2018) highlight the importance of crew resource management (CRM) training, which among others focuses on clear communication and team coordination (Wahl & Kongsvik, 2018). CRM training has been shown to reduce errors and improve safety (Salas et al., 2006).

Training programs must be designed to address the unique challenges of maritime communication, such as language barriers and cultural differences (Horck, 2006). Tailored training can significantly enhance safety outcomes (Frias et al., 2022). For example, simulation-based training provides realistic scenarios that help trainees practice and improve their communication skills in a controlled environment.

In addition to CRM, other communication training programs focus on specific aspects such as assertiveness and active listening (Milić-Beran et al., 2021). These skills are crucial for ensuring that all crew members feel comfortable voicing concerns and suggestions, which can prevent potential safety issues. Continuous improvement and adaptation of these training programs are necessary to keep pace with the evolving demands of the maritime industry.

Training programs must be designed to address the unique challenges of maritime communication, such as language barriers and cultural differences (Haqimin Mohd Salleh et al., 2019). Tailored training can significantly enhance safety outcomes (Helal, 2022).

4.0 Case Studies and Evidence

Evidence from various maritime organizations supports the effectiveness of communication training. For example, the Maritime and Coastguard Agency (MCA) implemented a comprehensive training program that led to a significant decrease in communication-related incidents (MCA, 2015). This program included both theoretical and practical components, ensuring that crew members could apply what they learned in real-world situations.

Similarly, the International Maritime Organization (IMO) emphasizes the importance of communication in its safety management guidelines (IMO, 2018). These guidelines serve as a benchmark for maritime organizations worldwide, encouraging the adoption of best practices in communication training. The success stories from different organizations underline the critical role of effective communication in enhancing maritime safety.

Table 1 shows a summary of communication elements that provide practical strategies to achieve a positive safety culture (Vecchio-Sadus, 2007). There is a need for improvement and adaptation of training programs to meet evolving safety challenges (Lützhöft et al., 2011). By means of regularly updating and refining training programs, maritime organizations can ensure that their crews are always prepared to communicate effectively in any situation.

Table 1: Safety Culture Communication Elements

Safety Culture Element	Requirement	Communication Element
Putting in place methods for controlling hazards	• Everyone shows support	• Displaying rules and procedures to remind everyone to work safely
Management commitment to minimising risks in the operations, and complying with all relevant health and safety legislation	• Accept responsibility for HSE • Become involved in HSE • Provide resources • Change attitude to risk	• Demonstrating the employer's personal commitment, values and expectations • Supervising and monitoring work performance
Employees contribute most effectively in an organisational culture based on trust and cooperation	• Atmosphere of trust, encouragement and reward in terms of HSE	• Assessing competency and providing revision of training when required • Providing feedback on HSE • Motivating staff • Recognising and rewarding achievement
Employees must be provided with the necessary information and training to broaden their knowledge and to gain new skills to behave and operate safely	• Willingness and competence to implement reforms and changes	• Providing instructions on how to work safely with equipment, tools, materials and processes
Employees contribute most effectively in an environment that provides a framework for consultation and communication	• Individuals encouraged and prepared to report errors and near-misses	• Meeting to discuss HSE issues such as hazard and incident reports, risk assessments and operating procedures

5.0 Teamwork and Leadership in Maritime Education

Teamwork and leadership are critical components of an effective safety culture (Hasanspahić et al., 2021). Strong leadership and cohesive teamwork can prevent accidents and improve overall safety performance (Hanzu-Pazara et al., 2012). In the maritime industry, the ability to work as a team is essential for efficient operations, especially during emergency situations where coordination and quick decision-making are crucial.

Effective teamwork ensures that all crew members are aware of their roles and responsibilities, leading to better coordination and fewer misunderstandings. Leadership, on the other hand, provides direction and motivation, helping to maintain high standards of safety and performance. Training programs that focus on these skills are vital for preparing maritime professionals to handle the complexities of their work environment.

Furthermore, leadership in maritime education involves not only managing tasks but also inspiring and guiding team members. Effective leaders can foster a positive safety culture by promoting open communication, encouraging collaboration, and recognizing the contributions of each team member. This holistic approach to leadership training ensures that maritime professionals are equipped to lead their teams effectively.

6.0 Training for Teamwork and Leadership

Training programs that focus on teamwork and leadership skills are essential for maritime safety. Such programs often incorporate simulations, role-playing, and scenario-based exercises to build practical skills (Sellberg, 2018). These interactive training methods help participants develop the skills needed to lead and work within a team effectively, even in high-pressure situations.

Simulations provide a realistic environment where trainees can practice their skills without the risks associated with real-life operations. The exercises help improve decision-making, communication, and coordination among team members. Role-playing and scenario-based training also allow participants to experience different leadership styles and team dynamics, helping them understand the importance of adaptability and flexibility in leadership.

Additionally, continuous professional development is crucial for maintaining and enhancing teamwork and leadership skills. Regular refresher courses and advanced training programs can help maritime professionals stay updated with the latest best practices and developments in the field. This ongoing training ensures that they can lead their teams effectively and maintain high standards of safety and performance.

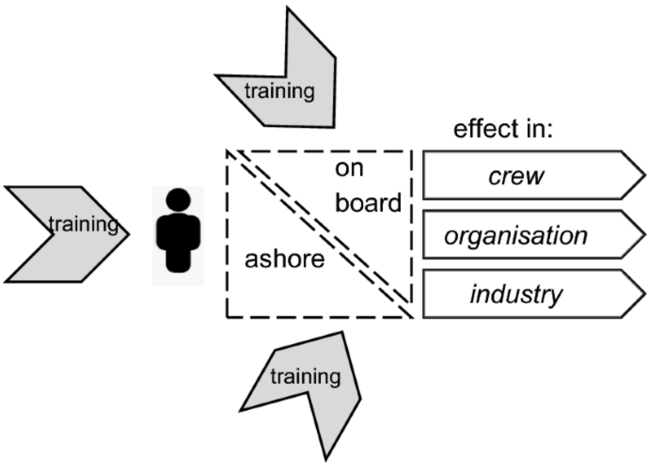

Figure 2: The multi-level leadership training and the effect in merchant shipping

Figure 2 shows that, instilling current and future seafarers with the principles of a leadership mindset, grounded in diverse and evolving leadership practices, holds the potential to generate advantages across all facets of the shipping industry (Progoulaki et al., 2022).

7.0 Evidence from the Field

Several studies highlight the positive impact of teamwork and leadership training. For instance, a study by (Burke et al., 2006) found that teams with enhanced training performed significantly better in crisis situations. This study demonstrated that well-trained teams could manage emergencies more effectively, reducing the likelihood of accidents and improving overall safety outcomes.

Another study by (Ationg et al., 2021) indicate that leadership training can be considered as a training that helps improve leader's decision-making skills and processes. Leaders who received training were better equipped to handle complex situations, make informed decisions, and guide their teams through challenges. These findings stress the importance of investing in leadership development programs to enhance safety and performance in maritime operations.

Real-world examples also highlight the benefits of teamwork and leadership training. For instance, maritime organizations that implemented comprehensive training programs reported significant improvements in safety performance and operational efficiency. These success stories provide valuable insights into the effectiveness of targeted training initiatives and emphasize the need for continuous improvement and adaptation of training programs.

Table 2: Descriptive Analysis of Soft Skills Before and After Training

Std. Deviation	Mean($_b$)	Soft Skills	Mean($_a$)	Std. Deviation
.73	3.83	Emotional Intelligence	4.07	.81
.79	3.64	Customer Handling Skills	4.10	.73
1.01	3.40	Professionalism	4.29	.55
.75	3.98	Planning & Organizing Skills	4.21	.81
1.13	3.26	Communication & Interpersonal Skills	4.02	.68
.94	3.57	Teamwork Skills	4.24	.73
1.01	3.40	Leadership Skills	4.19	.77
.98	3.33	Critical Thinking & Problem Solving Skills	4.12	.83

Table 2 shows a summary of the pre and post training descriptive research evaluating the efficacy of training on tourism graduates' ability to develop soft-skills necessary for professional success, emphasizing the importance of tailored training approaches (Chadha & Sharma, 2018). These programs highlight the need for ongoing assessment and refinement to maintain their effectiveness (Karimi & Pina, 2021).

8.0 Problem-Solving Skills and Safety Culture

Problem-solving skills are essential for managing unexpected situations and maintaining safety in maritime operations (Md. Mehadi Rahman, 2019). Training programs that enhance problem-solving abilities can significantly improve safety culture (Vecchio-Sadus & Griffiths, 2004). In the maritime industry, where unforeseen challenges and emergencies are common, the ability to think critically and solve problems quickly is crucial for ensuring safety and efficiency.

Effective problem-solving requires a combination of knowledge, experience, and critical thinking skills. Maritime professionals must be able to assess situations accurately, identify potential risks, and develop effective solutions. Training programs that focus on these skills can help individuals become more adept at handling complex and high-pressure situations.

Moreover, fostering a culture that values and encourages problem-solving can lead to significant improvements in safety outcomes. When team members feel empowered to identify and address issues proactively, it reduces the likelihood of accidents and enhances overall operational efficiency. This proactive approach to problem-solving is a key component of a strong safety culture in maritime operations.

10.0 Problem-Solving Training Approaches

Effective problem-solving training involves developing critical thinking, situational awareness, and decision-making skills (Ahmady & Shahbazi, 2020). Simulation-based training is particularly effective in this regard, allowing trainees to practice and refine their skills in a controlled environment (Michael Nnaemeka Ajemba et al., 2024). Simulations provide realistic scenarios that challenge trainees to apply their problem-solving skills and make decisions under pressure.

In addition to simulations, case studies and real-world examples can be used to teach problem-solving. These methods allow trainees to analyze past incidents, understand the factors that contributed to the problem, and develop strategies to prevent similar issues in the future. This analytical approach helps build a deeper understanding of problem-solving techniques and their application in maritime operations.

Collaborative problem-solving exercises are also beneficial. These exercises encourage teamwork and communication, helping trainees learn how to work together to identify and solve problems. By practicing these skills in a training environment, maritime professionals can develop the confidence and competence needed to handle real-world challenges effectively.

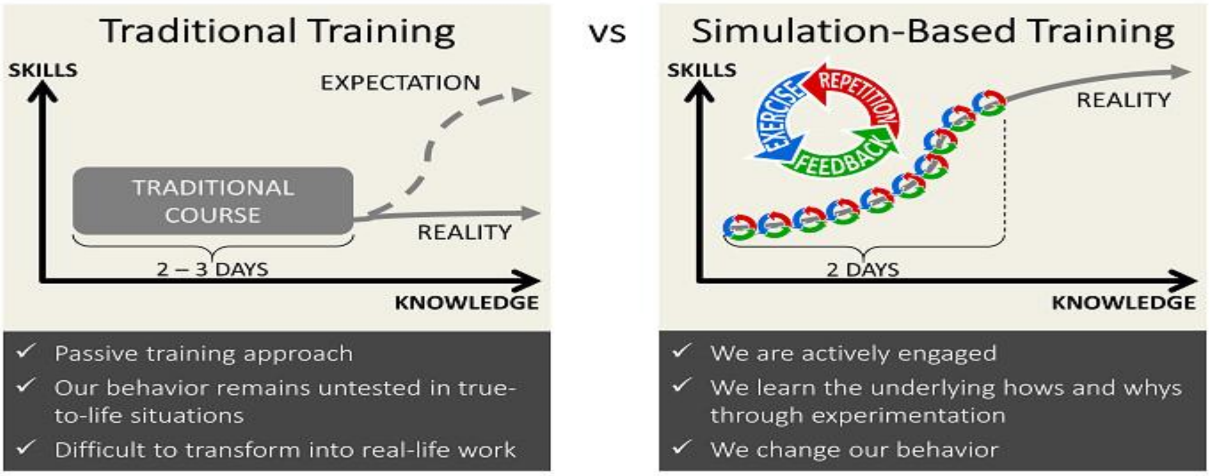

Fig. 3: Traditional Problem-Solving Training vs Simulation Based Training

Figure 3 shows the differences and outcome between traditional way of training and the simulation-based training in improving problem-solving skills. This approach provides realistic scenarios that enhance trainees' ability to manage real-world challenges (Lateef, 2010).

11.0 Real-World Applications and Outcomes

Research supports the effectiveness of problem-solving training. For example, a study by Chang et al (2017) found that simulation-based training improved situational awareness and decision-making skills. Participants who underwent this training were better equipped to handle complex situations, leading to improved safety outcomes and reduced error rates.

Another study by Babaei et al (2018)demonstrated that individuals with problem-solving abilities showed a reduction in errors and improved safety outcomes. Trainees who received comprehensive problem-solving training were more adept at identifying potential issues and implementing effective solutions, resulting in a safer and more efficient work environment.

Real-world applications of problem-solving training also highlight its benefits. Organizations within maritime industry that have integrated problem-solving training into their programs report significant improvements in safety performance and operational efficiency. These outcomes underscore the importance of investing in high-quality training programs to enhance problem-solving skills among maritime professionals.

Table 3: Deviation between Problem-Solving Training (PST) and Control Group at Pre and Post Testing Phases

	PST		Control	
	Pre-test	Post-test	Pre-test	Post-test
SPS	12.6 (1.9)	13.8 (2.1)	12.5 (2.8)	12.7 (2.6)
QoL	13.9 (2.8)	15.5 (3.1)	14.3 (2.4)	14.1 (3.2)
GHQ	12.3 (2.3)	13.92 (3.1)	12.7 (2.1)	12.54 (2.7)

PST=problem-solving training group, SPS=social problem solving, QoL= Quality of life, GHQ=mental health

To investigate the impact of problem-solving training on social problem-solving appraisal, quality of life, and mental health, a 2×2 repeated measures ANOVA was conducted. The intervention group (intervention vs. no intervention) was the between-groups variable, while the testing time (before vs. after the intervention) was the within-groups variable. Table 3 presents the means and standard deviations for these measures (Chinaveh, 2010).

12.0 Recommendations for Integrating Soft Skills Training

Integrating soft skills training into maritime education requires a strategic approach. This section provides recommendations for effective integration, focusing on curriculum development, instructor training, and continuous evaluation (Mohammed et al., 2023). A well-rounded strategy ensures that soft skills training is effectively incorporated into the overall educational framework, enhancing the safety culture within the maritime industry.

13.0 Curriculum Development

Developing a curriculum that incorporates soft skills training is essential. The curriculum should include modules on communication, teamwork, leadership, and problem-solving (Olugbenga, 2022). Using a mix of theoretical and practical training methods can enhance learning outcomes (Wrenn & Wrenn, 2009). This comprehensive approach ensures that trainees develop a solid foundation of knowledge and skills that can be applied in real-world situations.

Incorporating real-world scenarios and case studies into the curriculum can also enhance its effectiveness. These elements provide trainees with practical examples of how soft skills are applied in maritime operations, helping them understand the relevance and importance of these skills. Regular updates to the curriculum based on the latest research and industry practices ensure that it remains current and effective.

Additionally, engaging stakeholders, such as industry experts and experienced professionals, in the curriculum development process can provide valuable insights and ensure that the training meets the needs of the maritime industry. This collaborative approach helps create a curriculum that is both relevant and comprehensive, preparing trainees for the challenges they will face in their careers.

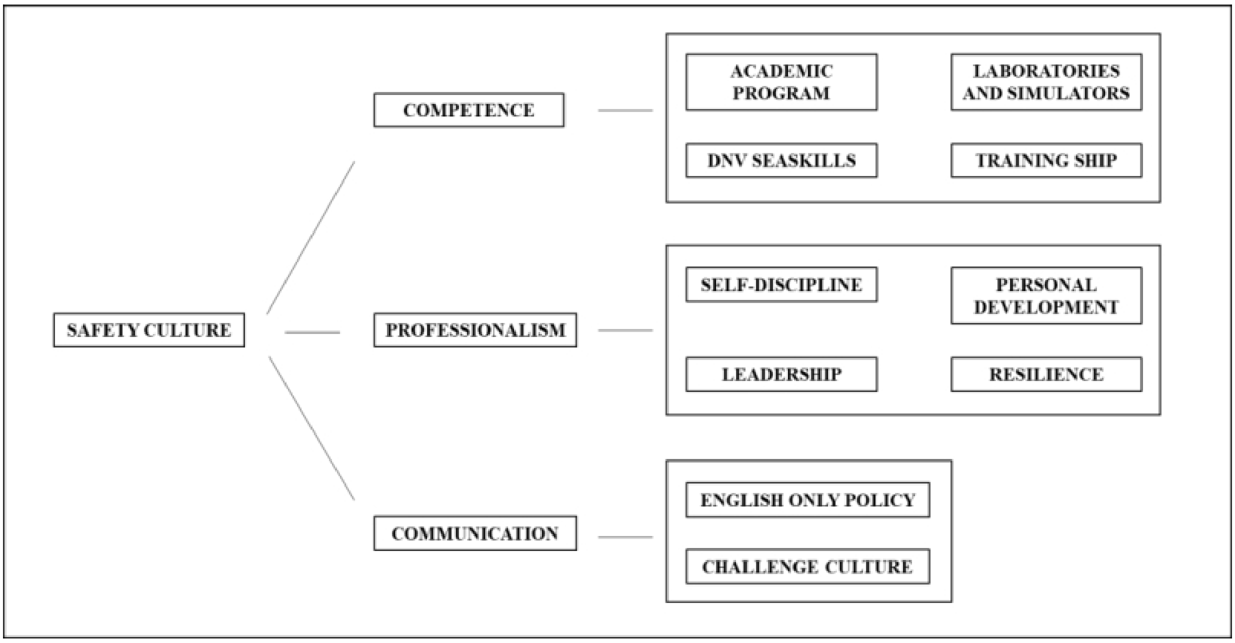

Fig. 4: Factors Contributing to Safety Culture

Figure 4 illustrates the integration of various soft skills training under the categories of competence, professionalism and communication, factors contributing to the enhancement of seafarer safety education. The curriculum should be regularly updated to reflect the latest research and industry practices. Hipol, A. J. V. (2022).

14.0 Instructor Training

Effective training requires skilled instructors. Instructors should receive comprehensive training to deliver soft skills training effectively (Ragusa et al., 2022). This training should include techniques for engaging trainees and assessing their progress (Salas & Cannon-Bowers, 2001). Well-trained instructors can create a dynamic and interactive learning environment that enhances the effectiveness of the training program.

Instructor training should also focus on developing the instructors' own soft skills. By enhancing their communication, leadership, and problem-solving abilities, instructors can serve as role models for trainees. This not only improves the quality of instruction but also reinforces the importance of soft skills in maritime operations.

Continuous professional development for instructors is crucial for maintaining high standards of training. Regular workshops, seminars, and refresher courses can help instructors stay updated with the latest best practices and developments in soft skills training. This ongoing learning ensures that they can deliver effective and relevant training to maritime professionals.

15.0 Continuous Evaluation

Continuous evaluation is crucial for maintaining the effectiveness of soft skills training programs. Regular assessments can identify areas for improvement and ensure that training remains relevant and effective (DEMİREL & BAYER, 2016). By collecting and analyzing feedback from trainees, instructors, and other stakeholders, organizations can gain valuable insights into the strengths and weaknesses of their training programs.

Evaluation methods should include both formative and summative assessments. Formative assessments, conducted throughout the training program, provide ongoing feedback that can be used to make immediate improvements. Summative assessments, conducted at the end of the program, evaluate the overall effectiveness of the training and identify areas for future development.

In addition to assessments, continuous evaluation should involve monitoring the long-term impact of the training on safety performance and operational efficiency. This can be done through follow-up surveys, performance reviews, and incident reports. By tracking these metrics, organizations can ensure that their soft skills training programs are achieving the desired outcomes and contributing to a safer maritime environment.

Table 4: Analysis of Soft Skills Before and After Training

Std. Deviation	$Mean_{(b)}$	Soft Skills	$Mean_{(a)}$	Std. Deviation
.73	3.83	Emotional Intelligence	4.07	.81
.79	3.64	Customer Handling Skills	4.10	.73
1.01	3.40	Professionalism	4.29	.55
.75	3.98	Planning & Organizing Skills	4.21	.81
1.13	3.26	Communication & Interpersonal Skills	4.02	.68
.94	3.57	Teamwork Skills	4.24	.73
1.01	3.40	Leadership Skills	4.19	.77
.98	3.33	Critical Thinking & Problem Solving Skills	4.12	.83

Table 4 shows an analysis of graduates' confidence in soft skills ability pre-test mean [Mean(b)] and post-test [Mean(a)]. Based on the assessments and evaluations carried out, an increase in mean scores after four months soft skills training for all the skills was evident (Chadha & Sharma, 2018).

16.0 Conclusion

Enhancing safety culture through effective soft skills training is vital for the maritime industry. Communication, teamwork, leadership, and problem-solving skills are crucial for preventing accidents and improving safety outcomes (Barnett et al., 2003). Integrating comprehensive soft skills training programs into maritime education can significantly enhance safety culture and reduce the incidence of maritime accidents (Olugbenga, 2022).

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Key Factors Influencing Learning Management System (LMS) Satisfaction Among Maritime Students: Insights from the Diploma Nautical Studies and Diploma Marine Engineering Programs

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Abstract - This study investigates student satisfaction with the Learning Management System (LMS) at the Akademi Laut Malaysia (ALAM), focusing on students enrolled in the Diploma Nautical Studies (DNS) and Diploma Marine Engineering (DME) programs. A quantitative research approach was employed, utilizing a structured questionnaire to collect data from 86 participants. The study analyses key factors influencing LMS satisfaction, including system content, instructional clarity, engagement, interaction, and perceived learning performance. Results indicate that while both DNS and DME students exhibit a generally positive level of satisfaction, DNS students report slightly higher mean satisfaction scores. Although the differences in satisfaction between the two groups were not statistically significant, the findings suggest variations in how the LMS meets the specific needs of each program. The study highlights the importance of optimizing LMS features to enhance student engagement and academic performance, particularly for DME students. Recommendations include improving content organization, engagement tools, and instructional materials to foster a more supportive learning environment.

Keywords: Learning Management System, student satisfaction, maritime education

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1.0 INTRODUCTION

The rapid advancement of technology has significantly transformed the educational landscape, with Learning Management Systems (LMS) emerging as a pivotal tool in supporting online and blended learning environments. LMS platforms, such as Moodle, Blackboard, and Canvas, are designed to facilitate the management of educational content, student engagement, communication, and performance tracking (Almaiah et al., 2020). As higher education institutions increasingly rely on LMS to enhance learning outcomes, understanding the factors that influence student satisfaction with these systems becomes crucial (Shahzad et al., 2021). In the context of maritime education, the use of LMS plays an important role in delivering flexible, accessible, and structured learning experiences. At the Akademi Laut Malaysia (ALAM), the LMS is widely used to support students enrolled in the Diploma Nautical Studies (DNS) and Diploma Marine Engineering (DME) programs. While LMS platforms are intended to streamline the learning process, their effectiveness is often determined by how students perceive the system's ease of use, engagement features, and overall support for academic performance (Baber, 2021). Consequently, student satisfaction with the LMS is a key indicator of its success and a critical measure for continuous improvement.

Numerous studies have explored the factors that influence LMS satisfaction, including system content, instructional clarity, engagement, interaction, and perceived learning performance (Al-Fraihat et al., 2020; Cheng et al., 2020). These factors contribute to how students engage with the platform and their overall satisfaction. However, there is limited research specifically focusing on the LMS experiences of maritime students, particularly comparing satisfaction levels between students from different academic programs such as DNS and DME. This study addresses this gap by investigating the factors influencing student satisfaction with the LMS at ALAM and comparing the experiences of DNS and DME students and to identify areas for enhancement to improve the learning experience and academic performance.

2.0 LITERATURE REVIEW

This section reviews relevant literature focusing on key factors influencing student satisfaction with Learning Management Systems (LMS), including system content, instructional information, engagement, interaction, learning performance, perceived LMS, and perceived students' satisfaction. These factors provide a framework for understanding how LMS usage affects students' experiences and academic outcomes in higher education.

2.1 System Content and Organization

The organization and accessibility of content in an LMS play a critical role in shaping student satisfaction. Poor content structure or difficulty in navigating materials can lead to frustration and hinder learning. Studies have highlighted the importance of clear and intuitive content organization, noting that students prefer systems where materials are well-organized and easy to find (Shahzad et al., 2021). Research suggests that content organization impacts how efficiently students engage with the LMS, directly influencing their learning outcomes (Almaiah et al., 2020). An LMS that allows for easy access to relevant course content, assignments, and resources can significantly enhance student satisfaction and overall learning experience (Cheng et al., 2020).

2.2 Instructional Information and Clarity

Instructional clarity within the LMS is another key factor influencing student satisfaction. The quality and comprehensibility of instructions provided through the LMS can either enhance or impede students' ability to use the system effectively. Clear and well-structured instructional materials are associated with higher levels of student satisfaction, as they reduce confusion and increase the efficiency of learning processes. Almaiah et al., (2020) highlight that unclear instructional design often results in poor student engagement and learning experiences, emphasizing the need for easily accessible tutorials and guidelines. Research also shows that students benefit from multimedia instructional aids, such as video tutorials or interactive guides, which further support understanding and ease of use (Shahzad et al., 2021).

2.3 Student Engagement

Student engagement within the LMS is critical to maintaining high levels of satisfaction. Engaging students through interactive features, such as quizzes, discussion forums, and gamified learning elements, has been shown to significantly increase their motivation and satisfaction with the system (Vanduhe, 2020). Gamification has been found to enhance both the learning experience and student participation, creating a more dynamic and enjoyable educational environment (Baber, 2021). Moreover, research indicates that systems that provide personalized feedback and progress tracking features help maintain engagement by giving students a sense of accomplishment and control over their learning journey (Alraimi et al., 2020). These features, when effectively integrated into the LMS, foster an engaging and supportive learning environment that positively impacts satisfaction.

2.4 Interaction and Communication

Effective communication between students and instructors, as well as among students themselves, is a fundamental aspect of successful LMS use. Studies show that systems facilitating both synchronous and asynchronous communication tend to improve student satisfaction, as they allow for more flexible and accessible interaction (Mishraa et al., 2020). Real-time chat functions, forums, and discussion boards enable students to connect with peers and instructors, thereby promoting collaborative learning (Bond et al., 2020). Furthermore, LMS platforms that support frequent and transparent communication are more likely to create a sense of community, which is essential for student engagement and satisfaction (Cheng et al., 2020). However, limitations in communication tools, such as delayed responses or complex interfaces, can reduce satisfaction, particularly when students struggle to access support when needed (Baber, 2021).

2.5 Learning Performance and Outcomes

Research consistently shows that students' perception of how well an LMS supports their learning performance strongly influences their satisfaction with the system (Shah et al., 2021). LMS platforms that provide tools for tracking progress, accessing grades, and managing assignments tend to foster a more structured and efficient learning environment (Al-Fraihat et al., 2020). Shahzad et al., (2021) found that students who perceive the LMS as contributing positively to their academic success are more likely to engage with the system and report higher satisfaction levels. In contrast, when LMS features are seen as inadequate for supporting academic achievement, students may become disengaged and dissatisfied (Almaiah et al., 2020). Therefore, systems that not only organize learning content effectively but also actively support students in achieving their academic goals are more likely to lead to positive educational outcomes.

2.6 Perceived Learning Management System (LMS)

Perceptions of the LMS itself—its ease of use, usefulness, and technical stability—are essential in determining students' satisfaction and continued use. Studies show that when students perceive the LMS as easy to navigate and useful for their academic work, they are more likely to engage with it consistently and report higher satisfaction levels (Al-Fraihat et al., 2020). Baber (2021) notes that students who perceive the LMS as user-friendly and adaptable to their learning needs tend to achieve better academic outcomes. Additionally, Shahzad et al., (2021) found that technical issues or a lack of system reliability can significantly diminish students' perceptions of the LMS, ultimately lowering their satisfaction. Therefore, a well-designed LMS that aligns with students' expectations for functionality and reliability is crucial for maintaining satisfaction.

2.7 Perceived Students' Satisfaction

Perceived student satisfaction with the LMS reflects their overall experience with the platform and its ability to support their academic and personal needs. Studies indicate that satisfaction is multifaceted, involving elements such as the quality of content delivery, ease of interaction with peers and instructors, and the effectiveness of the system in facilitating learning (Alraimi et al., 2020). Cheng et al., (2020) found that when students perceive the LMS as enhancing their academic performance and engagement, their overall satisfaction increases. Additionally, Vanduhe (2020) suggest that personalized learning experiences, where the LMS adapts to students' learning styles and progress, significantly contribute to higher satisfaction levels. Therefore, perceived satisfaction is a critical outcome of the LMS experience and can serve as a key indicator of the system's success in supporting students' academic journeys.

3.0 RESEARCH METHODOLOGY

This research employed a robust quantitative approach to assess student satisfaction with the Learning Management System (LMS) in ALAM's Diploma Nautical Studies (DNS) and Diploma Marine Engineering (DME) programs. Utilizing a descriptive and comparative research design, the study involved 86 participants, capturing both their overall satisfaction and the key influencing factors. Data was gathered through a structured questionnaire using a 5-poin Likert scale, allowing for a precise measurement of satisfaction levels. The analysis incorporated descriptive statistics to summarize satisfaction, an independent t-test to identify significant differences between the DNS and DME groups, and Cronbach's Alpha to ensure the survey instrument's reliability. Additionally, mean scores were ranked to pinpoint the most influential satisfaction factors.

Convenience sampling was employed due to the accessibility and relevance of the student cohort, acknowledging the potential limitations in generalizability. Ethical considerations were meticulously addressed; participants were informed about the study's purpose, assured of their anonymity, and provided informed consent. Despite constraints like sample size and the inherent bias of convenience sampling, the methodology was judiciously selected to meet the study's objectives. The quantitative approach facilitated precise comparisons and statistical validation, offering actionable insights for LMS enhancement at ALAM. This rigorous methodology provides a valuable foundation for understanding and improving LMS satisfaction in the maritime educational context.

4.0 ANALYSIS AND DISCUSSION

4.1 Factor Validation

Here are the **Cronbach's Alpha** values for each factor group, which indicate the internal consistency of the survey responses.

Table 1. Cronbach's Alpha values for each factor

Factor	Cronbach's Alpha Value
System Content	0.864
Instruction Information	0.760
Interaction	0.812
Engagement	0.966
Learning Performance	0.916
Student Satisfaction	0.903
Overall	**0.975**

All factors having the Cronbach's Alpha values between 0.70 and 0.90 are ideal, reflecting good internal consistency (Alotaibi,2022; Li et al., 2023).

4.2 Independent t-test

Here is the t-test result

Table 2. t-test result

Statistic	Value
t-value	1.24
p-value	0.22

This table shows the t-statistic and p-value from the independent t-test conducted to compare the overall LMS satisfaction between DNS and DME students. As the p-value (0.22) is greater than the significance level (0.05), the difference in satisfaction between the two groups is not statistically significant.

4.3 Comparison of student satisfaction

The comparison of student satisfaction between DNS and DME programs reveals that DNS students have a higher mean satisfaction score of 4.09. DME students have a slightly lower mean satisfaction score of 3.89. This suggests that DNS students are slightly more satisfied with the LMS than DME students. This difference could indicate varying perceptions or experiences between the two groups when using the LMS.

Table 3. Mean Value for each factor

Factor	DNS Mean	DME Mean
System Content	3.91	3.59
Instruction Information	3.95	3.72
Interaction	3.89	3.65

Engagement	4.06	3.74
Learning Performance	4.13	3.78
Student Satisfaction	4.09	3.89

This section presents the analysis of the collected data and discusses the findings in the context of the existing literature. The analysis focuses on key factors influencing student satisfaction with the Learning Management System (LMS) at the Akademi Laut Malaysia (ALAM), specifically comparing the satisfaction levels of students in the Diploma Nautical Studies (DNS) and Diploma Marine Engineering (DME) programs.

4.3.1. Overall Satisfaction with the LMS

The findings indicate that both DNS and DME students express a generally positive level of satisfaction with the LMS, with DNS students reporting a slightly higher mean satisfaction score (4.09) compared to DME students (3.89). Although the independent t-test results ($t = 1.24$, $p = 0.22$) show no statistically significant difference between the two groups, the difference in mean satisfaction levels suggests that DNS students perceive the LMS more favourably. This could be attributed to variations in how the LMS aligns with the specific learning needs and curriculum structure of the two programs. The overall positive satisfaction aligns with existing literature, which suggests that LMS platforms, when properly designed and managed, can provide valuable support to students in higher education (Al-Fraihat et al., 2020). However, the slight difference in satisfaction between DNS and DME students suggests that further customization or optimization may be needed to cater to the specific needs of DME students, potentially improving their engagement and academic performance.

4.3.2. System Content and Organization

The system content factor emerged as one of the most important for both DNS and DME students. However, DNS students rated this factor more positively (mean score: 3.91) compared to DME students (mean score: 3.59). This difference suggests that DNS students find the organization and accessibility of the content in the LMS more suitable for their learning style and program requirements. According to (Shahzad et al., 2021), well-organized content in an LMS can significantly enhance students' satisfaction by making resources easy to access and use. For DME students, the lower satisfaction with system content may indicate that the LMS does not align as well with their specific academic needs. Improving content structure, ensuring clear categorization, and providing easier access to course materials could improve satisfaction for DME students (Almaiah et al., 2020).

4.3.3. Instructional Information and Clarity

Instructional information and clarity were similarly rated by both DNS and DME students, though DNS students reported slightly higher satisfaction (mean score: 3.95) compared to DME students (mean score: 3.72). This factor encompasses how clearly the LMS conveys instructions, assignments, and learning expectations to students. Previous studies have shown that when instructions are clear and easy to follow, students experience less frustration and greater satisfaction with the system (Owusu-fordjour et al., 2020). The difference in satisfaction may reflect varying levels of complexity in the curricula for DNS and DME programs. DNS students may find the instructional design within the LMS better suited to their needs, while DME students may benefit from additional clarity in the presentation of instructional materials. Incorporating multimedia tutorials and interactive guides can help both groups but may be especially beneficial for DME students (Almaiah et al., 2020).

4.3.4. Student Engagement and Interaction

Engagement and interaction were key factors influencing satisfaction, with DNS students rating engagement higher (mean score: 4.06) compared to DME students (mean score: 3.74). DNS students also rated interaction (mean score: 3.89) higher than DME students (mean score: 3.65). This suggests that DNS students perceive the LMS as more engaging and supportive of communication between peers and instructors. The literature supports the idea that engagement tools, such as discussion forums, real-time chats, and interactive quizzes, enhance the learning experience and increase student satisfaction (Vanduhe, 2020). The slightly lower engagement and interaction scores among DME students may indicate that they are not fully utilizing or benefiting from these features. Improving the functionality of interactive tools or providing additional opportunities for collaborative learning could enhance their experience (Mishraa et al., 2020).

4.3.5. Learning Performance and Outcomes

Both DNS and DME students rated learning performance as a key factor in their satisfaction with the LMS, with DNS students again reporting higher satisfaction (mean score: 4.13) than DME students (mean score: 3.78). The perceived contribution of the LMS to academic success and performance was significant for both groups, but DNS students felt that the LMS had a greater positive impact on their learning outcomes. Previous research has shown that when students perceive the LMS as directly contributing to their academic performance, they are more likely to engage with the system and report higher satisfaction (Shah et al., 2021). The lower satisfaction score among DME students could indicate that the LMS tools and resources are less aligned with their specific learning objectives. Enhancing the LMS's ability to support assignment submissions, grading, and academic progress tracking could help address this gap (Al-Fraihat et al., 2020).

4.3.6. Perceived LMS and Student Satisfaction

Perceptions of the LMS's usability, usefulness, and reliability play a significant role in determining overall student satisfaction. DNS students generally perceived the LMS more favourably than DME students, which is reflected in the slightly higher satisfaction scores across all factors. Baber (2021) found that user-friendly LMS platforms that are seen as reliable and easy to navigate result in higher student satisfaction. For DME students, improving the perceived ease of use and addressing technical issues could boost their overall satisfaction with the system (Shahzad et al., 2021).

The analysis highlights that while DNS students report slightly higher satisfaction across all factors, there is no statistically significant difference between DNS and DME students' overall satisfaction with the LMS. Factors such as system content, engagement, interaction, and learning performance emerged as critical for both groups, with DNS students consistently rating the LMS more favourably. The findings suggest that while the LMS at ALAM is generally effective, there is room for improvement, particularly in addressing the needs of DME students. Enhancing the LMS's content organization, improving engagement tools, and providing clearer instructional materials could result in a more positive experience for all students. Additionally, addressing technical issues and ensuring that the LMS is perceived as reliable and easy to use could further increase student satisfaction.

4.4 Areas of enhancement

Based on the research paper's findings, the following areas of enhancement are identified to improve student satisfaction with the LMS at ALAM.

4.4.1 Content Organization and Accessibility.

Enhance course content organization by using a standardized format, clear labels, and centralized resources to improve accessibility, especially for DME students who reported lower satisfaction in this area.

4.4.2 Instructional Clarity and Support.

Improve instructional clarity by adding multimedia elements and offering instructor training. Provide students with support resources like FAQs and tutorials for clearer, more comprehensive learning materials.

4.4.3 Student Engagement and Interaction.

Boost student engagement by adding interactive features like forums, real-time chats, quizzes, and gamified activities. Tailor collaboration tools and gamification to each program's curriculum for active participation.

4.4.4 Personalized Learning Experience.

Tailor LMS features for DNS and DME students by using adaptive learning paths and personalized dashboards to track progress and offer targeted feedback, creating a more personalized learning experience.

4.4.5 Technical Stability and Usability.

Improve LMS stability and usability by conducting regular audits, offering responsive technical support, and gathering student feedback to quickly resolve technical and usability issues for a seamless experience.

4.4.6 Communication Tools.

Enhance communication by adding timely notifications, instant messaging, and virtual office hours in the LMS to improve interactions between students and instructors, fostering a more supportive learning environment.

4.4.7 Learning Performance Tracking.

Enhance learning performance tracking by adding grade tracking, assignment feedback, and self-assessment tools in the LMS, helping students monitor progress and set academic goals effectively.

By focusing on these areas, the LMS can be optimized to better support the diverse learning needs of DNS and DME students, thereby enhancing overall student satisfaction and academic outcomes.

5.0 CONCLUSION

The study concluded that while students in both Diploma Nautical Studies (DNS) and Diploma Marine Engineering (DME) at ALAM generally express positive satisfaction with the Learning Management System (LMS), DNS students report slightly higher satisfaction levels. Key factors influencing this satisfaction include system content, engagement, interaction, and learning performance. The findings suggest that the LMS effectively supports students' academic experiences but also indicate potential areas for improvement, particularly in enhancing the LMS experience for DME students through better content organization and engagement tools.

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Evaluating Hydrogen and Ammonia as Sustainable Alternatives for Marine Diesel Engines: Environmental, Technical, and Economic Perspectives

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Abstract - The maritime industry is a notable contributor to global greenhouse gas (GHG) emissions, necessitating a transition to low-carbon alternatives to mitigate environmental impact. This study explores hydrogen and ammonia as potential alternative fuels for marine diesel engines, focusing on their environmental benefits, technical feasibility, and economic considerations. Hydrogen, with its high energy density and zero carbon emissions at the point of use, offers a promising solution for sustainable maritime operations. Ammonia, characterized by its high hydrogen content and renewable production capabilities, presents a viable alternative despite its associated challenges. The review assesses the current state of research and development, examining the comparative emissions profiles, storage and handling requirements, and combustion characteristics of these fuels. Technical barriers, such as advanced storage solutions for hydrogen and safety measures for ammonia, are discussed alongside economic obstacles, including high initial investment costs and fuel price disparities. Regulatory frameworks and policy support are highlighted as critical factors for successful adoption. Case studies of hydrogen and ammonia applications in maritime contexts underscore the practical feasibility and collaborative efforts necessary for broader implementation. The paper concludes by identifying future research directions to enhance the viability of hydrogen and ammonia as sustainable marine fuels, contributing to the maritime sector's transition towards reduced environmental impact and alignment with global climate goals.

Keywords: Alternative Fuels, Ammonia Fuel, Hydrogen Fuel, Marine Diesel Engines, Maritime Emissions, Sustainable Maritime,

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1.0 INTRODUCTION

The maritime sector is a significant contributor to global GHG emissions, accounting for approximately 2.5% of the world's total emissions (IMO, 2021). To mitigate environmental impact, the industry must transition to low-carbon alternatives. Hydrogen and ammonia have emerged as promising candidates for alternative marine fuels due to their potential for reducing emissions and reliance on fossil fuels.

Hydrogen, with its high energy density and zero carbon emissions at the point of use, offers a viable solution for sustainable maritime operations (Ryu et al., 2023). Ammonia, on the other hand, provides a high hydrogen content and can be produced from renewable energy sources, making it an attractive alternative (Giddey et al., 2017). Both fuels, however, present unique challenges and opportunities that require detailed examination.

This review aims to assess the feasibility and impact of hydrogen and ammonia as alternative fuels. It will explore the environmental benefits, technical requirements, and economic considerations associated with their adoption. By examining the current state of research and development, this paper seeks to provide a comprehensive understanding of the potential of these fuels in achieving sustainable maritime operations.

2.0 ENVIRONMENTAL IMPACT OF HYDROGEN AND AMMONIA FUELS

The environmental impact of hydrogen and ammonia as alternative marine fuels is a critical consideration in their adoption. Hydrogen, when used as a fuel, produces only water as a by-product, eliminating CO2 emissions entirely (Lin et al., 2023). These characteristic positions hydrogen as a leading candidate for reducing the maritime industry's carbon footprint.

Ammonia, although not entirely carbon-free, can be produced using renewable energy sources through processes such as electrolysis, thereby minimizing its overall environmental impact (Smith et al., 2020). The combustion of ammonia in marine engines can produce nitrogen oxides (NOx), but advanced catalytic converters and selective catalytic reduction (SCR) systems can mitigate these emissions effectively (Zhu et al., 2022).

In addition to reducing GHG emissions, the adoption of hydrogen and ammonia fuels can significantly decrease sulfur oxides (SOx) and particulate matter (PM) emissions, contributing to improved air quality in port cities and coastal areas (Ni et al., 2020). Furthermore, the utilization of renewable energy for hydrogen and ammonia production aligns with global efforts to transition to sustainable energy systems (IEA, 2019). Table 1 showing Comparison of Emissions from Hydrogen, Ammonia, and Conventional Marine Fuels.

Fuel	LHV (MJ/kg)	HHV (MJ/kg)	Stoichiometric Air/FuelRatio (kg)	Combustible Range (%)	Flame Temp(°C)	Min. Ignition Energy (MJ)	Auto Ignitin Temp. (°C)
Methne	50.0	55.5	17.2	5-15	1914	0.30	540-630
Propane	45.6	50.3	15.6	2.1-9.5	1925	0.30	450
Octane	47.9	15.1	0.31	0.95-6	1980	0.26	415
Methanol	18.0	22.7	6.5	6.7-36	1870	0.14	460
Hydrogen	119.9	141.6	34.3	4-75	2207	0.017	585
Gasoline	44.5	47.3	14.6	1.3-7.1	2307	0.29	260-460
Diesel	42.5	44.8	14.5	0.6-5.5	2327	-	180-320

Table 1: Comparison of Emissions from Hydrogen, Ammonia, and Conventional Marine Fuels (Kumar et al., 2015).

Hydrogen and ammonia also offer the potential for reducing marine plastic pollution. Traditional marine fuels can contribute to plastic waste through leakage and spillage, whereas hydrogen and ammonia do not pose such risks. This aspect further enhances their suitability as sustainable alternatives.

3.0 TECHNICAL FEASIBILITY OF HYDROGEN AND AMMONIA AS MARINE FUELS

The technical feasibility of hydrogen and ammonia as marine fuels involves evaluating their storage, handling, and combustion characteristics. Hydrogen, due to its low density, requires advanced storage solutions such as compressed gas cylinders or liquid hydrogen tanks (Van Hoecke et al., 2021). These storage methods must ensure safety and efficiency, particularly in maritime environments.

Ammonia, with its higher energy density compared to hydrogen, presents fewer storage challenges. It can be stored as a liquid under moderate pressure or refrigeration, making it more practical for long-distance maritime transport (Duong et al., 2023). However, ammonia's toxicity necessitates stringent safety measures to prevent leaks and ensure crew safety.

Combustion characteristics also play a vital role in determining the feasibility of these fuels. Hydrogen can be used in internal combustion engines (ICEs) and fuel cells, each offering different advantages. Fuel cells provide higher efficiency and lower emissions, while ICEs offer easier integration with existing maritime infrastructure (Onorati et al., 2022).

Ammonia can be used in ICEs with modifications to address its lower flame speed and higher ignition temperature. Dual-fuel engines that use a combination of ammonia and conventional fuels can enhance combustion efficiency and reduce emissions (Cardoso et al., 2021). Figure 1showing Schematic Diagram of Ammonia Fuel Systems for Marine Engines

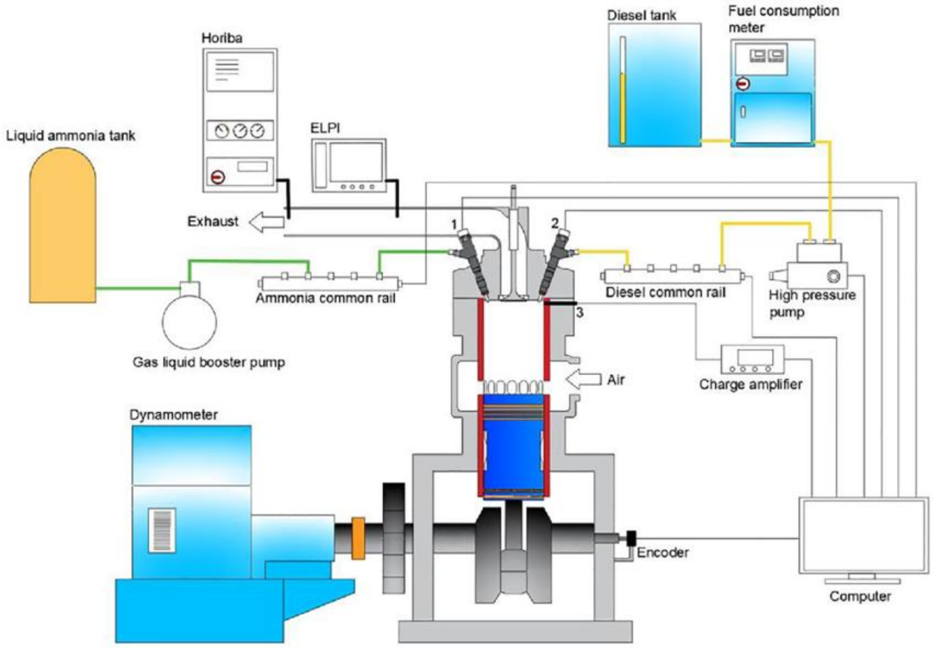

Fig. 1. Schematic Diagram of Ammonia Fuel Systems for Marine Engines (Zhang et al., 2023)

4.0 CHALLENGES AND BARRIERS TO ADOPTION

Despite the potential benefits, several challenges and barriers must be addressed to facilitate the adoption of hydrogen and ammonia as marine fuels. Technical challenges include the development of efficient storage and handling systems, as well as the optimization of combustion processes (Van Hoecke et al., 2021). Safety concerns, particularly regarding ammonia's toxicity, must be thoroughly addressed through stringent regulations and best practices (Duong et al., 2023).

Economic barriers, such as high initial investment costs and the current price disparity between alternative and conventional fuels, pose significant obstacles (Wang et al., 2021). Bridging this gap will require substantial financial incentives and support from governments and international organizations. Regulatory and policy challenges also play a critical role. Harmonizing international regulations and standards for alternative marine fuels is essential to ensure consistent implementation and compliance (IMO - Marine Environment Protection Committee, 2020). Furthermore, public acceptance and awareness are crucial for the successful transition to hydrogen and ammonia fuels.

Collaboration across the maritime industry, including shipbuilders, engine manufacturers, fuel producers, and policymakers, is vital to overcome these challenges. Research and development efforts must focus on innovative solutions to enhance the feasibility and competitiveness of hydrogen and ammonia fuels (Kim et al., 2020).

5.0 CASE STUDIES AND REAL-WORLD APPLICATIONS

Several case studies and pilot projects demonstrate the practical application of hydrogen and ammonia as marine fuels. The world's first hydrogen-powered passenger ferry, Hydro Ville, operates in Belgium, showcasing the feasibility of hydrogen for short-distance maritime transport. The Ship FC project in Norway aims to retrofit an offshore supply vessel with a large-scale ammonia fuel cell system, providing valuable insights into the challenges and opportunities associated with ammonia as a marine fuel (Jafarzadeh et al., 2023). These initiatives highlight the potential of hydrogen and ammonia to transform the maritime industry.

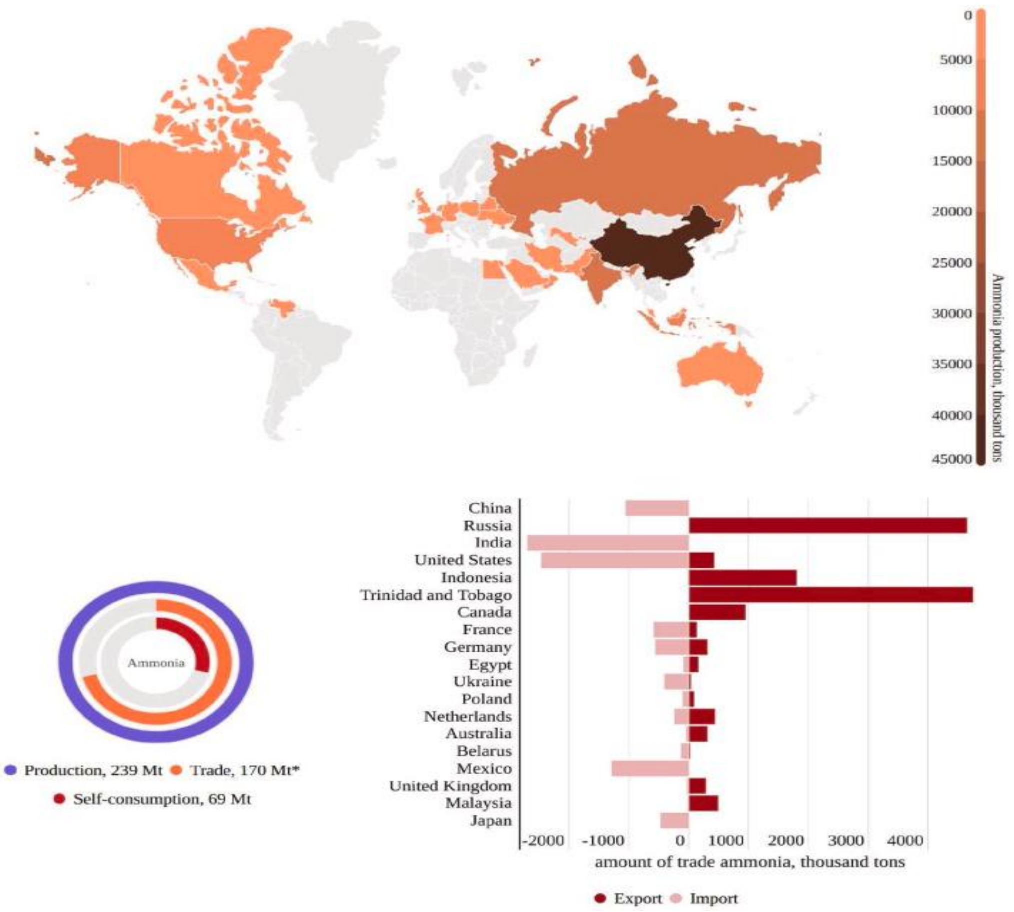

Fig. 2. Global ammonia production per country with import and export details (Machaj et al., 2022)

These case studies also underscore the importance of collaboration and knowledge sharing in advancing alternative fuel technologies. Lessons learned from these projects can guide future research and development efforts, facilitating the broader adoption of hydrogen and ammonia fuels in the maritime sector (Hansson et al., 2019).

6. FUTURE DIRECTIONS AND RESEARCH OPPORTUNITIES

Future research should focus on optimizing the production, storage, and utilization of hydrogen and ammonia fuels. Advances in electrolysis and other renewable energy-based production methods can reduce costs and improve sustainability (Marouani et al., 2023). Innovative storage solutions, such as metal hydrides and advanced tank designs, can enhance the practicality of hydrogen and ammonia for maritime applications (Bellosta von Colbe et al., 2019).

Policy and regulatory frameworks should continue to evolve to support the adoption of alternative marine fuels. Incentives for research and development, infrastructure investments, and early adopters can accelerate the transition to sustainable maritime solutions (IMO, 2021).

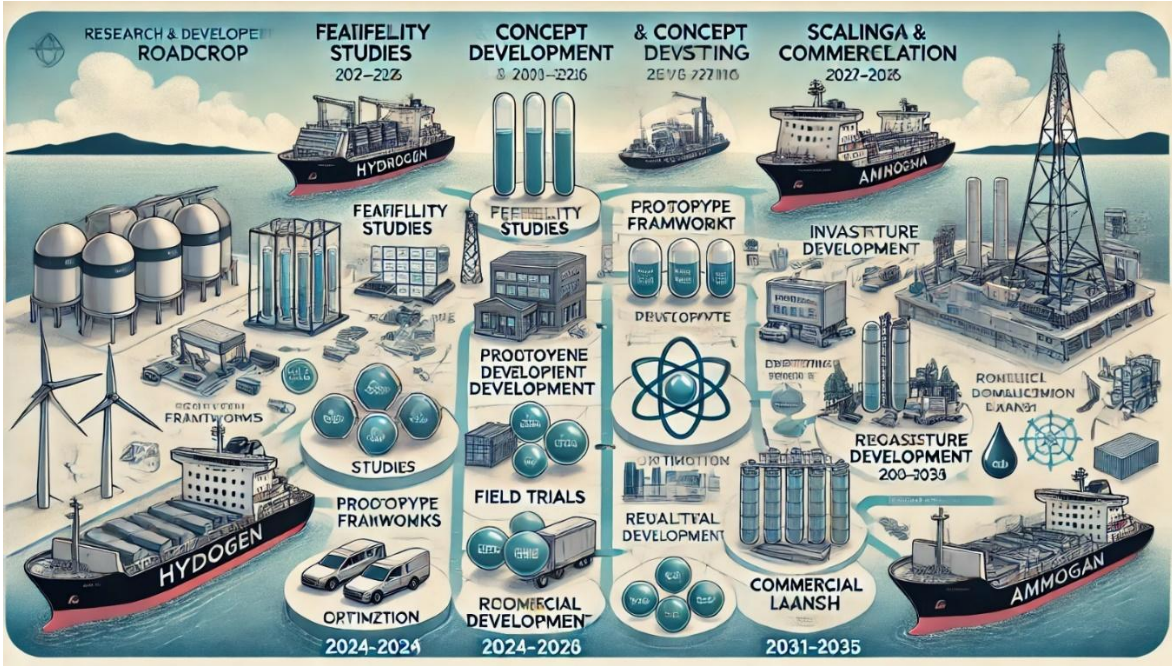

Fig. 3. Illustration Research and Development Roadmap for Hydrogen and Ammonia Fuels in the Maritime Industry

7. CONCLUSION

The transition to hydrogen and ammonia as alternative fuels for marine diesel engines offers a promising pathway to achieving sustainable maritime operations. While challenges remain, the environmental benefits, technical feasibility, and economic potential of these fuels make them viable options for the future of the maritime industry.

Continued research, innovation, and collaboration are essential to overcome the barriers and unlock the full potential of hydrogen and ammonia fuels. By embracing these alternative fuels, the maritime sector can significantly reduce its environmental impact and contribute to global efforts to combat climate change.

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A Holistic Study on Renewable Energy Solutions for Marine Vessels

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Abstract - The maritime industry is under increasing pressure to reduce its environmental impact, particularly its greenhouse gas (GHG) emissions. The adoption of renewable energy technologies on board ships is seen as a crucial step toward achieving this goal. This review article provides an in-depth analysis of the current state of renewable energy integration on ships, focusing on the technologies available, their applications, and the challenges faced. It also explores the future potential of these technologies and their role in meeting international environmental regulations. The article concludes with recommendations for further research and development in this field.

Keywords: Renewable energy, maritime industry, GHG emissions, renewable integration, maritime sustainability

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1.0 INTRODUCTION

The maritime industry contributes significantly to global GHG emissions, accounting for nearly 2.5% of the world's total carbon dioxide (CO_2) emissions (Fun-sang Cepeda et al., 2019). Figure 1 shows global GHG emission contribution by the maritime industry. This has led to a growing emphasis on the need to reduce the environmental footprint of ships, particularly through the adoption of renewable energy technologies. The integration of renewable energy on board ships not only supports global environmental goals but also offers economic benefits by reducing fuel consumption and operating costs (Wang et al., 2023).

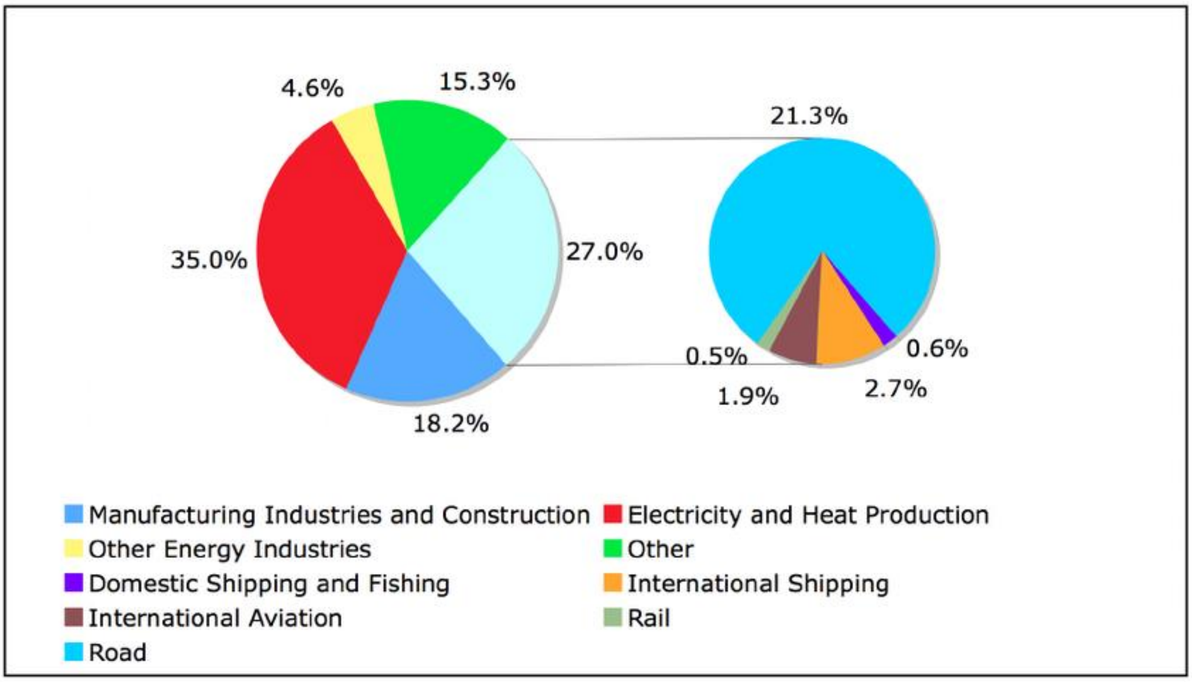

Fig. 1. Global GHG emissions contribution by the maritime industry (Yoo et al., 2022)

The primary sources of renewable energy considered for maritime use include wind, solar, and biofuels. These technologies have the potential to significantly reduce the dependency on fossil fuels and lower GHG emissions (Pan et al., 2021). However, the integration of these technologies on board ships presents several technical, economic, and regulatory challenges that need to be addressed (Animah et al., 2023). Table 1 shows the overview of renewable energy technologies used in maritime applications. There are several benefits and challenges for each technology that uses renewable energy. This review aims to explore these challenges and provide a comprehensive overview of the current state of renewable energy integration in the maritime industry.

Table 1: Overview of renewable energy technologies used in maritime applications (Huang et al., 2022)

Technology	Description	Applications in Maritime Industry	Benefits	Challenges
Solar Energy	Utilizes photovoltaic (PV) panels to convert sunlight into electricity.	Used for auxiliary power on ships, lighting, and electricity generation.	Reduces fuel consumption and emissions, especially in sunny regions.	Space constraints on ships, efficiency varies with sunlight availability and weather conditions.
Wind Energy	Harnesses wind power using sails, rotors, or kites for propulsion and electricity generation.	Wind-assisted ship propulsion, including rigid sails, Flettner rotors, and kites.	Significant fuel savings and emissions reductions, especially on long ocean voyages.	Dependence on wind conditions, integration with existing propulsion systems.
Biofuels	Renewable fuels derived from biological sources like algae, waste oils, and agricultural residues.	Can be used in existing marine engines with minimal modifications.	Reduces GHG emissions and can be produced from waste materials.	High production costs, availability, and potential competition with food production.
Hydrogen Fuel Cells	Converts hydrogen into electricity through a chemical reaction, producing only water as a byproduct.	Used in combination with electric propulsion systems for zero-emission ships.	Zero emissions, high efficiency, and can be produced from renewable energy sources.	Storage and handling of hydrogen, high costs, and limited infrastructure.
Hybrid Systems	Combines multiple energy sources, such as solar, wind, and conventional	Hybrid power systems for fishing vessels, cargo ships, and passenger ships.	Increased reliability, reduced fuel consumption, and flexibility in	Complex integration and high initial investment.

	fuels, to optimize energy use.		energy management.	
Battery Storage	Stores energy generated from renewable sources for later use.	Used to store energy for electric propulsion and auxiliary systems on ships.	Enhances energy efficiency, provides backup power, and reduces reliance on conventional fuels.	Limited storage capacity, high costs, and weight considerations.

2.0 RENEWABLE ENERGY INTEGRATION IN THE MARITIME INDUSTRY.

The maritime industry, a key player in global trade, is exploring renewable energy sources to reduce greenhouse gas emissions and transition towards more sustainable operations. Technologies such as wind-assisted propulsion, solar energy systems, and biofuels offer promising alternatives to traditional fossil fuels. Wind energy, used for centuries, has seen modern advancements in rotor sails and kite sails, which can significantly cut fuel consumption. Solar panels provide an efficient way to generate electricity on ships, reducing reliance on diesel engines. Biofuels derived from organic materials also offer a renewable alternative, though their large-scale adoption faces challenges. Together, these innovations hold the potential to reshape the maritime sector into a cleaner, more sustainable industry.

2.1 Wind Energy

Wind energy has been harnessed by the maritime industry for centuries, but modern advancements in wind technology offer new opportunities for reducing emissions. The use of wind-assisted propulsion systems, such as rotor sails and kite sails, can significantly cut fuel consumption and emissions (Seddiek & Ammar, 2021). These systems are particularly effective on routes with consistent wind patterns, providing a viable complement to traditional engines. Despite its potential, wind energy integration on ships faces several challenges. The variability of wind conditions can affect the reliability of these systems, and their installation may require significant modifications to the ship's design (Thies & Ringsberg, 2023). Moreover, the economic feasibility of wind-assisted propulsion depends on the specific operational profile of the ship, including its speed and route (Mason et al., 2023).

Recent case studies demonstrate the effectiveness of wind energy systems in reducing fuel consumption by up to 20%, with a corresponding reduction in CO2 emissions (Svendsen et al., 2022). However, widespread adoption remains limited due to the high initial costs and the need for further technological advancements (Veers et al., 2023). Future research should focus on improving the efficiency and reliability of wind energy systems to make them more viable for large-scale maritime applications. Figure 2 shows the floating offshore wind turbines that are commonly used nowadays.

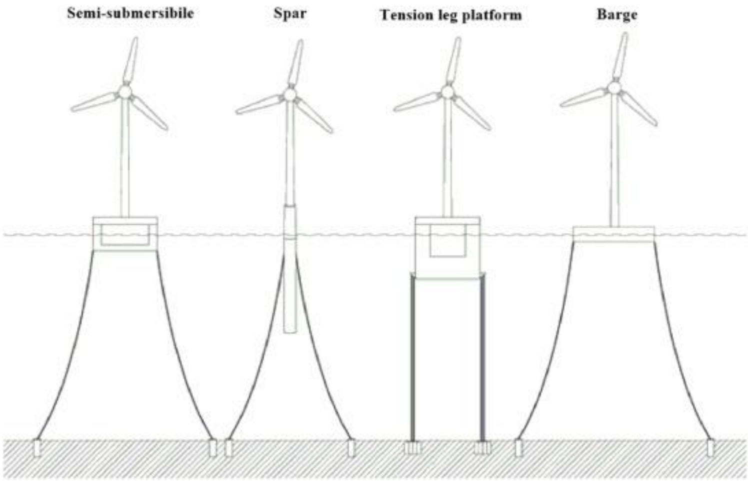

Fig 2: Floating offshore wind turbine (Yu et al., 2022)

2.2 Solar Energy

Solar energy is another promising source of renewable energy for the maritime industry. Solar panels can be installed on the deck and superstructures of ships to generate electricity for auxiliary systems, reducing the load on diesel generators and cutting emissions (Serris et al., 2023). Solar energy is particularly attractive because of its reliability and low maintenance requirements.

However, the integration of solar panels on ships is limited by space constraints and the efficiency of current photovoltaic technology. The amount of energy generated depends on the surface area available for panel installation and the amount of sunlight received, which varies with the ship's location and weather conditions (Tuswan et al., 2022). Additionally, the initial investment cost for solar panel installation is high, which may deter shipowners from adopting this technology (Esmailian et al., 2019).

Despite these challenges, solar energy has been successfully implemented on several ships, resulting in significant fuel savings and emission reductions. For instance, the MS Tûranor PlanetSolar, a solar-powered catamaran, demonstrated the viability of solar energy for maritime applications by completing a round-the-world voyage in 2012 (Tuswan et al., 2022). Table 2 shows the comparison of energy generation and efficiency of different solar technologies on ship. Future developments in photovoltaic technology and energy storage systems could further enhance the potential of solar energy on board ships.

Table 2: Comparison of energy generation and efficiency of different solar technologies on ships (Dawoud et al., 2023)

Solar Technology	Energy Generation Efficiency	Key Findings	Applications on Ships
Conventional Photovoltaic (PV)	Efficiency varies based on latitude and orientation, typically around 15-20%.	PV systems on ships reduce fuel consumption and GHG emissions significantly. PV output fluctuates with ship movement, but hybrid systems can smooth these fluctuations.	Commonly used for auxiliary power on ships. Can be combined with diesel generators and batteries.
Solar-Thermal Systems	Efficiency depends on the design; typically, lower than PV but useful for heating.	Solar-thermal systems are effective for reducing reliance on fossil fuels for heating on ships but require specific design adaptations due to the movement of the ship.	Can be integrated with ship systems for thermal energy demands.
Hybrid PV/Diesel/Battery Systems	Efficiency depends on the balance of components; typically, around 20-30%.	Hybrid systems combining PV with diesel and batteries significantly reduce fuel consumption and GHG emissions, offering a reliable and cost-effective solution for ships operating on various routes.	Optimal for reducing GHG emissions and ensuring power reliability.
Hybrid Solar PV/PEM Fuel Cell/Diesel	Varies with conditions, high efficiency in optimal setups	Integration of solar PV with PEM fuel cells and diesel generators provides a cleaner and more efficient power generation method, reducing dependency on fossil fuels and minimizing emissions.	Ideal for cruise ships and vessels requiring continuous power.

2.3 Biofuels

Biofuels offer a renewable alternative to conventional marine fuels, with the potential to reduce GHG emissions significantly. Figure 3 shows biofuel production process and its environmental impacts. These fuels, derived from biological sources such as algae, waste oils, and agricultural residues, can be used in existing ship engines with minimal modifications (Mukherjee et al., 2020). The use of biofuels aligns with the IMO's strategy to reduce CO2 emissions from international shipping by at least 40% by 2030(Sullivan & Rossi, 2023).

However, the adoption of biofuels in the maritime industry is hindered by several factors. The availability and cost of biofuels remain significant challenges, as large-scale production is required to meet the energy demands of the shipping industry (Mukherjee et al., 2020). Additionally, the sustainability of biofuels is a concern, as the production process can have environmental impacts, including deforestation and competition with food production (Tudge et al., 2021).

Despite these challenges, there have been successful trials of biofuels on ships, demonstrating their potential to reduce emissions. For example, Maersk conducted a pilot project using algae-based biofuel, which resulted in a 90% reduction in CO2 emissions compared to traditional marine fuel (Xiao et al., 2022). Continued research and development are needed to improve the efficiency and sustainability of biofuels for maritime use.

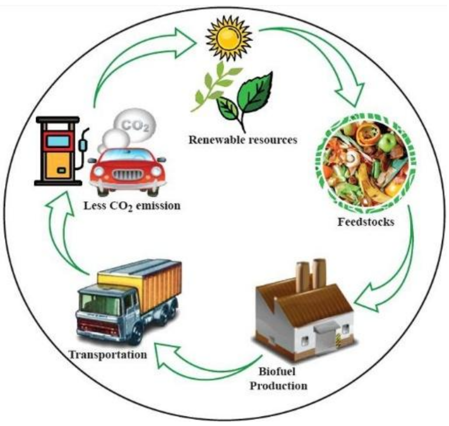

Fig 3: Biofuel production process and its environmental impacts (Malode et al., 2021)

3.0 CHALLENGES AND FUTURE PROSPECTS

The integration of renewable energy technologies on board ships is not without its challenges. Technical limitations, high initial costs, and regulatory barriers are significant obstacles that need to be addressed. The lack of standardized guidelines for the implementation of these technologies further complicates their adoption (Pan et al., 2021). Additionally, the maritime industry's conservative nature and resistance to change may slow the transition to renewable energy (Issa et al., 2022).

To overcome these challenges, coordinated efforts from industry stakeholders, including shipowners, technology providers, and regulatory bodies, are essential. Policies and incentives that encourage the adoption of renewable energy technologies on ships can play a crucial role in accelerating this transition. Furthermore, continued research and development are necessary to enhance the efficiency, reliability, and cost-effectiveness of these technologies (Pan et al., 2021).

The future of renewable energy on board ships looks promising, with several innovative technologies on the horizon. Advances in wind and solar energy systems, coupled with the development of sustainable biofuels, could significantly reduce the maritime industry's environmental impact (Issa et al., 2022). However, achieving widespread adoption will require overcoming the existing challenges and fostering a culture of innovation and sustainability within the industry. Table 3 shows the key challenges and solutions for renewable energy integration on ships.

Table 3: Key challenges and solutions for renewable energy integration on ships

Challenge	Description	Potential Solutions	References
Technical Limitations	Renewable energy systems like solar and wind are dependent on environmental conditions and can be less reliable than conventional systems.	Develop hybrid systems that combine renewable energy with conventional power sources to ensure reliability and consistent energy supply.	(Pan et al., 2021)
Space Constraints	Limited space on ships for installing large solar panels or wind turbines.	Optimize the design and placement of renewable energy systems to maximize efficiency within the available space.	(Salem & Seddiek, 2016)
High Initial Costs	Significant upfront investment is required for the installation of renewable energy systems on ships.	Provide financial incentives, subsidies, or low-interest loans to reduce the initial cost burden for shipowners.	(Issa et al., 2022)
Regulatory Barriers	Lack of standardized guidelines and varying regulations across regions make the adoption of renewable technologies more complex.	Develop international standards and regulations to streamline the adoption process and ensure consistency across regions.	(Stevens et al., 2015)
Energy Storage	Efficient storage of energy generated from renewable sources is challenging due to the intermittent nature of these sources.	Invest in advanced energy storage technologies, such as high-capacity batteries, to store excess energy for later use.	(Pense & Akinoglu, 2020)
Maintenance and Durability	Renewable energy systems require regular maintenance and may be more vulnerable to harsh marine environments.	Design renewable energy systems with marine-grade materials and invest in preventive maintenance strategies to enhance durability.	(Nuchturee et al., 2020)
Economic Feasibility	The cost-effectiveness of renewable energy systems may be questioned, especially in the face of fluctuating fuel prices.	Conduct thorough cost-benefit analyses and highlight the long-term savings and environmental benefits of renewable energy systems.	(Bach et al., 2021)

Integration with Existing Systems	Integrating new renewable technologies with existing ship systems can be complex and may require significant retrofitting.	Develop modular renewable energy systems that can be more easily integrated with existing infrastructure on ships.	(Ling-Chin & Roskilly, 2016)
Environmental Impact of Production	The production of renewable energy technologies, such as solar panels and batteries, can have its own environmental footprint.	Invest in greener manufacturing processes and recycling programs to minimize the environmental impact of renewable energy technologies.	(Bach et al., 2021)

Conclusion

The integration of renewable energy solutions for marine vessels is a vital step toward reducing the maritime industry's environmental footprint, particularly its GHG emissions. As demonstrated in this review, renewable technologies such as wind-assisted propulsion, solar energy, biofuels, hydrogen fuel cells, and hybrid systems present viable alternatives to fossil fuels, each offering distinct advantages and challenges. While wind and solar energy have shown promise in reducing fuel consumption and emissions, space constraints, variable environmental conditions, and high initial investment costs remain significant barriers. Biofuels, although offering a renewable solution, face challenges related to production sustainability and cost.

For renewable energy technologies to gain widespread adoption in the maritime industry, coordinated efforts from ship owners, regulators, and technology providers are essential. Incentives and international regulations can help address financial and regulatory challenges, while continuous research and development will improve the efficiency, durability, and cost-effectiveness of these systems. As advancements in energy storage and hybrid systems continue to evolve, the future of maritime sustainability looks promising. However, overcoming the existing barriers requires a concerted effort to foster innovation and a long-term commitment to environmental stewardship within the industry.

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The Impact of Cybersecurity on the Maritime Industry and its Solutions

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Abstract - The maritime industry, a critical component of global trade and commerce, has become increasingly dependent on digital technologies for operations, navigation, and communication. This growing reliance has exposed the industry to a range of sophisticated cyber threats, from ransomware attacks to GPS spoofing, phishing, and data breaches. These threats have the potential to disrupt operations, compromise safety, and lead to significant financial losses. This review article explores the impact of cybersecurity on the maritime industry and examines various solutions to mitigate these risks. The discussion covers the evolving nature of cyber threats, the implications for maritime operations, and the strategic measures implemented to enhance cybersecurity. Through a comprehensive analysis of existing literature, this article aims to provide insights into the current state of maritime cybersecurity and propose future directions for research and practice. This review highlights the necessity for robust cybersecurity frameworks to ensure the safety and efficiency of maritime operations.

Keywords: Cybersecurity, Cyber Threats, Cyber Risk, Digital Technologies Mitigation, Maritime Industry

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1.0 INTRODUCTION

The maritime industry, integral to global trade and commerce, is increasingly dependent on digital technologies. This reliance, while enhancing operational efficiency, also introduces significant cybersecurity vulnerabilities (Mednikarov et al., 2020, Akpan et al., 2022). Maritime cybersecurity encompasses the protection of shipborne systems, shore-based operations, and communication networks against cyber threats (Melnyk et al., 2023). These threats can disrupt operations, endanger lives, and cause substantial financial losses (Caprolu et al., 2020).

Cyber threats in the maritime sector have evolved, with attackers employing sophisticated methods to exploit vulnerabilities. Incidents such as the 2017 NotPetya attack, which severely impacted Maersk's operations across multiple ports and resulted in financial losses estimated at $300 million, highlight the maritime sector's vulnerability to cyber threats (Meyer-Larsen & Müller, 2018). The increasing integration of Internet of Things (IoT) devices further exacerbates these vulnerabilities (Ashraf et al., 2023). As maritime operations become more digitized, the potential for cyber-attacks grows, necessitating robust cybersecurity measures (Caprolu et al., 2020). Table 1 which is adapted from Akpan et al. (2022) presents examples of recent cyber incidents in the maritime transport sector.

Table 1. Examples of recent cyber incidents

Year	Incident	Consequences
2016	GPS jamming attack in South Korea	280 vessels were affected
2017	Cyberattack against the navigation system	Hijack of the vessel for 10 h
2017	Cyberattack against the navigation system	U.S. Navy ship collided with a boat
2017	NotPetya malware attack	Affected shipping infrastructures

2018	GPS spoofing attack against ships in the Black Sea	Deviation of 20 ships to an airport
2018	Remotely compromising onboard computers	Stealing sensitive data
2018	GPS spoofing attack	Manipulation of the ship position
2018	ECDIS was infected by a virus	Delay in the ship sailing
2019	Malware attack targeted a U.S. vessel	Critical credential mining
2020	Ransomware Hermes 2.1. attack on 2 ships	Infection of the whole network
2020	Ransomware attack "Mespinoza/Pysa"	Maritime infrastructures infected
2021	Ransomware attack on shipping companies	All their files were encrypted
2022	Installation of malicious code	Gain access to the port network

Table 1. Examples of recent cyber incidents in the maritime transport sector (Adapted from Akpan et al., 2022)

Effective cybersecurity in the maritime industry involves a multi-faceted approach, including technological, organizational, and regulatory strategies (Farah et al., 2023). Technological measures such as encryption, intrusion detection systems, and secure communication protocols are essential for enhancing cybersecurity in maritime systems (Walid et al., 2017). Organizational strategies include training personnel in cybersecurity best practices and developing incident response plans (Chowdhury et al., 2022).Regulatory frameworks at national and international levels play a crucial role in standardizing and enforcing cybersecurity practices (Faria, 2020).

This article aims to provide a comprehensive review of the impact of cybersecurity on the maritime industry and the solutions implemented to address these challenges. By analyzing current literature, this review will identify key trends, highlight effective practices, and propose future research directions.

2.0 CYBERSECURITY THREATS IN THE MARITIME INDUSTRY

Cyber threats in the maritime industry can take various forms, including malware, phishing, ransomware attacks, Denial-of-Service (DoS) attacks, GPS spoofing, and data breaches (Ashraf et al., 2023; Caprolu et al., 2020; Androjna et al., 2020). These threats can disrupt navigation systems, compromise cargo security, and lead to financial losses.

Malware and phishing attacks are common in the maritime industry. These attacks often target email systems and can lead to unauthorized access to sensitive data. Notably, the NotPetya attack in 2017, which affected Maersk's operations, highlighted the devastating impact of cyber-attacks on maritime logistics, causing an estimated financial loss of $200–300 million (Meyer-Larsen & Müller, 2018).

Ransomware attacks involve encrypting a company's data and demanding payment for its release. In the maritime sector, such attacks can halt operations, delay shipments, and result in significant financial losses (Pawelski, 2023). The impact is amplified by the interconnected nature of global supply chains.

GPS spoofing involves sending false signals to a vessel's navigation system, causing it to deviate from its intended course. This can lead to collisions, groundings, and other maritime accidents (Androjna & Perkovič, 2021; Wang et al., 2022). The vulnerability of navigation systems to spoofing attacks underscores the need for robust cybersecurity measures. Denial-of-service attacks, on the other hand, overwhelm systems with traffic, causing disruptions (Akpan et al., 2022). These attacks can delay shipments and increase operational costs.

Data breaches in the maritime industry can expose sensitive information, including cargo manifests, crew details, and financial transactions (Mednikarov et al., 2020; Akpan et al., 2022). Such breaches not only pose security risks but also damage the reputation of maritime companies.

Human error and insider threats are significant concerns in maritime cybersecurity. Unintentional mistakes or malicious actions by employees can lead to security breaches. Training and awareness programs are essential to mitigate these risks (Amoresano & Yankson, 2023). Table 2 which is adapted from Ukwandu et al. (2022) presents the distribution types of Cyber Attacks.

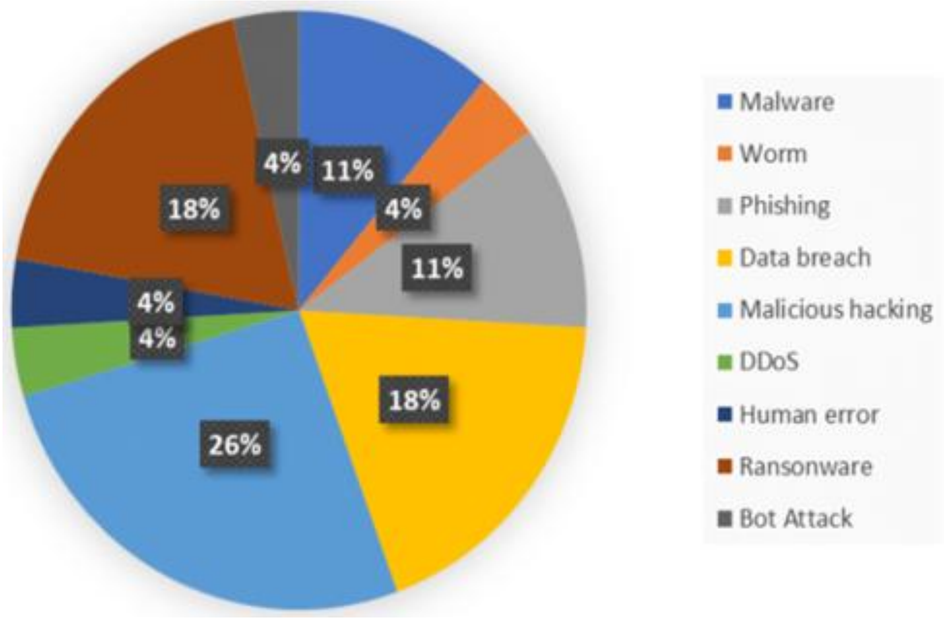

Figure 1: Distribution of Cyber Attacks by Type (Adapted from Ukwandu et al., 2022)

3.0 VULNERABILITIES IN MARITIME INFRASTRUCTURE

The maritime industry's growing reliance on digital systems for managing operations, navigation, and communications has led to significant vulnerabilities that are increasingly being exploited by cyber attackers. This dependence on digital technologies is compounded by the widespread use of legacy systems, a lack of standardization, and inadequate cybersecurity policies, all of which contribute to the sector's susceptibility to cyber threats. The maritime industry is highly interconnected, and any breach in a single system can have widespread implications across the global supply chain. This makes it essential to address the underlying issues that expose the industry to cyber risks (Mednikarov et al., 2020).

One of the primary challenges faced by maritime companies is the continued use of outdated software and hardware systems. Many maritime organizations operate with legacy systems that were not designed to withstand modern cyber threats. These systems are often more prone to attacks due to inherent security weaknesses, including vulnerabilities that are no longer supported by software updates or patches (Ashraf et al., 2023). Updating these systems is a complex and costly process, requiring significant investment in both technology and personnel. However, failing to update these systems leaves critical maritime infrastructure vulnerable to cyberattacks that could disrupt operations, cause financial losses, and even compromise the safety of vessels and ports.

The lack of standardization across the maritime industry further exacerbates these vulnerabilities. This absence of standardized cybersecurity measures creates inconsistencies in how companies approach cybersecurity, with some organizations implementing more rigorous protections than others. As a result, gaps in security across the industry make it easier for cybercriminals to exploit weaknesses in the global maritime infrastructure (Finley & Harkiolakis, 2018). Establishing international cybersecurity standards is crucial for mitigating these risks.

Another critical vulnerability is the absence of comprehensive cybersecurity policies across many maritime companies. Without robust policies that outline clear cybersecurity protocols, response plans, and mitigation strategies, these organizations remain highly vulnerable to attacks (Akpan et al., 2022). It is essential that maritime companies not only develop but also rigorously implement detailed cybersecurity policies tailored to their specific operational needs.

4.0 SOLUTIONS TO ENHANCE MARITIME CYBERSECURITY

Addressing cybersecurity within the maritime industry is a complex challenge that requires a comprehensive and multifaceted approach. The maritime sector is highly interconnected and relies on a combination of digital technologies for operations, communications, and navigation. As such, a broad set of strategies must be implemented to adequately defend against the increasing sophistication and frequency of cyber threats. Key components of this approach include the integration of advanced technological solutions, the development of strong regulatory frameworks, and fostering collaboration between industry stakeholders (Hopcraft & Martin, 2018).

One of the most critical aspects of improving cybersecurity in the maritime sector is the implementation of advanced technological solutions. Technologies such as intrusion detection systems (IDS), encryption, and blockchain have become essential tools in protecting maritime assets from cyberattacks. Intrusion detection systems help monitor and identify suspicious activities within networks, enabling rapid response to potential breaches. Encryption technologies ensure that data transmitted between systems, whether onshore or at sea, is protected from unauthorized access, thus preserving data integrity. Blockchain technology adds an additional layer of security by enabling secure, tamper-proof transactions and communications (Caprolu et al., 2020; Sanober et al., 2022; Meng et al., 2018). These technologies are vital in safeguarding sensitive information, maintaining operational continuity, and reducing the risk of cyberattacks that could disrupt maritime operations. By employing these advanced cybersecurity technologies, maritime organizations can better protect critical systems from being compromised.

In addition to technological solutions, the establishment of robust regulatory frameworks is paramount for ensuring cybersecurity across the maritime sector. These frameworks provide a structured and enforceable approach to mitigating cyber risks by setting minimum standards for cybersecurity practices. For example, international regulatory bodies such as the International Maritime Organization (IMO) have developed guidelines on maritime cyber risk management, which provide a foundational set of standards that shipping companies, ports, and other maritime stakeholders can follow to enhance their cybersecurity measures. These guidelines address areas such as network security, data protection, and incident response, ensuring that cybersecurity is embedded within the broader safety management system of maritime organizations (Hopcraft & Martin, 2018; Faria, 2020).

Another critical element in addressing cybersecurity in the maritime industry is collaboration between different stakeholders, including maritime companies, cybersecurity firms, and governmental agencies. Cybersecurity is a collective responsibility, and no single entity can effectively mitigate cyber risks on its own. By fostering cooperation and collaboration across sectors, maritime organizations can share valuable information on threats, vulnerabilities, and best practices, helping to create a unified and coordinated defense against cyber threats. Collaborative efforts can take many forms, from joint cybersecurity exercises and incident response drills to sharing intelligence on emerging cyber threats and attack methodologies. (Caprolu et al., 2020). This collaborative approach not only strengthens the industry's overall cybersecurity posture but also helps in developing more resilient systems that are better equipped to withstand and respond to cyber incidents.

5.0 FUTURE DIRECTIONS AND RESEARCH

Future research in maritime cybersecurity should prioritize the development of more sophisticated and targeted technologies and strategies that address the specific needs and vulnerabilities of the maritime industry. The unique operational challenges of the maritime sector, including the integration of complex shipborne and shore-based systems, require tailored cybersecurity solutions that can mitigate risks and ensure the smooth functioning of global maritime operations. Advancements in cybersecurity technologies should not only focus on protecting these systems but also anticipate potential future threats, making proactive security a cornerstone of maritime operations (Farah et al., 2023).

In addition to technological advancements, continuous training and education for maritime professionals are critical for maintaining a high level of cybersecurity awareness. The rapidly evolving nature of cyber threats means that personnel must be regularly updated on the latest risks and best practices. Training programs must go beyond basic cybersecurity protocols to include in-depth education on the specific challenges faced by the maritime industry, ensuring that employees can respond effectively to cyber incidents and reduce the risk of human error, a common factor in security breaches (Kayisoglu et al., 2023; Canepa et al., 2021; Pyykkö et al., 2020).

Emerging technologies such as artificial intelligence (AI) and machine learning (ML) are poised to play a crucial role in enhancing cybersecurity within the maritime industry. These technologies offer promising solutions for the detection and mitigation of cyber threats by improving the capacity for real-time monitoring, threat detection, and rapid response. AI and ML technologies can analyze vast amounts of data to identify anomalies that may indicate potential threats, thus providing early warning systems that can help prevent cyberattacks before they occur (Kumar et al., 2023). These technologies can also be leveraged to automate certain aspects of cybersecurity, reducing the burden on human operators and allowing for more efficient responses to emerging threats.

Finally, the continuous development and refinement of cybersecurity policies are essential to keeping pace with the rapidly evolving cyber threat landscape. Cybersecurity policies should be regularly reviewed and updated to address new vulnerabilities and emerging threats. This process should include a comprehensive assessment of existing cybersecurity measures and the integration of new technologies and strategies that can enhance overall system security. Furthermore, cybersecurity policies must be aligned with international standards and best practices to ensure a coordinated and unified response to threats across the maritime sector (Finley & Harkiolakis, 2018). By maintaining robust and adaptive cybersecurity policies, the maritime industry can better protect its critical infrastructure from cyberattacks, ensuring the safety and efficiency of global maritime operations.

6.0 CONCLUSION

Cybersecurity is a crucial issue for the maritime industry, impacting every aspect of operations and safety. As digital technologies become more embedded in maritime infrastructure, the industry faces heightened risks from cyber threats. To effectively protect against these risks, it is vital to understand the nature of the threats, identify vulnerabilities, and implement robust security measures. This requires a multifaceted approach, including the adoption of advanced cybersecurity technologies, adherence to regulatory standards, and the development of comprehensive cybersecurity policies. Collaboration between industry stakeholders, cybersecurity experts, and governmental agencies is essential for building a unified defense, while ongoing research and innovation are critical for staying ahead of evolving cyber threats. Through collaboration, regulation, and continuous improvement, the maritime industry can enhance its cybersecurity posture and safeguard against future cyber-attacks.

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Enhancing Maritime Vocabulary Acquisition for Ratings at Akademi Laut Malaysia Through Gamification

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Abstract - The integration of gamification in education has emerged as a transformative approach to enhance learning outcomes, particularly in specialized fields such as maritime training. This review explores the effectiveness of gamification in maritime vocabulary acquisition among ratings at Akademi Laut Malaysia. Traditional methods of vocabulary instruction often fail to engage students and meet their diverse learning needs. By applying game design elements in non-game contexts, gamification offers interactive and immersive learning experiences that significantly improve motivation, engagement, and retention of maritime terminology. This study synthesizes existing research on gamification in education, with a particular focus on its application in maritime training. Key strategies discussed include the use of digital flashcards, narrative-driven quests, and simulations that create competitive yet collaborative learning environments. The findings underscore the potential of gamification to bridge the gap between theoretical learning and real-world application, making vocabulary acquisition more effective and enjoyable. However, successful implementation requires careful alignment with educational objectives, inclusivity, and adequate resource allocation. Challenges such as ensuring intrinsic motivation and addressing inequalities among students are also considered. By providing a comprehensive analysis, this review contributes to understanding how gamification can revolutionize maritime education and better prepare ratings at Akademi Laut Malaysia for their professional roles. Future research directions are suggested further to explore the long-term impacts of gamification on learning outcomes and to develop best practices for its effective implementation in maritime training programs.

Keywords: Gamification, Maritime Vocabulary, Ratings, Akademi Laut Malaysia, Educational Technology

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1.0 INTRODUCTION

The integration of gamification in education has gained significant attention as a means to enhance learning outcomes. Gamification, defined as applying game design elements in non-game contexts, has increased motivation and engagement in various educational settings (Deterding et al., 2011). This review examines its application in maritime vocabulary acquisition for ratings at Akademi Laut Malaysia, an essential aspect of maritime training (Hamari et al., 2014).

Maritime education, particularly for ratings, necessitates a robust vocabulary to ensure effective communication and operational efficiency. Traditional methods of vocabulary acquisition often need more engagement and cater to the diverse learning needs of students (Landers, 2014). Gamification presents an innovative solution, offering interactive and immersive learning experiences that can significantly enhance vocabulary retention and application (Domínguez et al., 2013).

The theoretical foundation for gamification in education is rooted in constructivist theories, emphasising active and experiential learning. Gamification can create a competitive yet collaborative learning environment by incorporating elements such as points, badges, and leaderboards (Werbach & Hunter, 2020). This approach aligns with the needs of maritime training, where practical application and teamwork are crucial (Buckley & Doyle, 2016).

This review aims to synthesise existing research on gamification in maritime education, evaluate its effectiveness in vocabulary acquisition, and provide recommendations for implementation at Akademi Laut Malaysia. By doing so, it contributes to the broader discourse on educational technology and its potential to transform traditional learning paradigms (Huang & Soman, 2013). This review includes a Gamification framework for maritime vocabulary acquisition, illustrated in Figure 1 below.

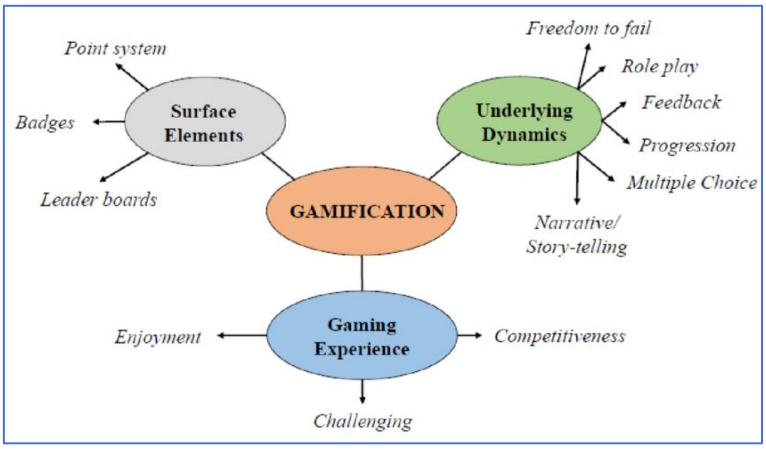

Figure 1: Gamification Framework: Surface Elements, Underlying Dynamics and Game Effects (Langendahl et al., 2016)

2.0 GAMIFICATION IN EDUCATION

The concept of gamification has evolved significantly, with a growing body of literature supporting its efficacy in various educational contexts. Research indicates that gamification can enhance student motivation, engagement, and academic performance by leveraging intrinsic and extrinsic rewards (Sailer et al., 2017). In maritime education, where practical skills and knowledge are paramount, gamification can bridge the gap between theoretical learning and real-world application (Iosup & Epema, 2014).

Studies have demonstrated that gamification can facilitate deeper learning by promoting active participation and fostering a sense of accomplishment. For instance, Li et al. (2012) found that students who engaged in gamified learning activities showed improved retention and understanding of complex concepts. Similarly, Su and Cheng (2015) reported that gamification enhanced students' willingness to participate and collaborate, leading to better learning outcomes. Table 1 provides a detailed comparison of traditional versus gamified learning outcomes, highlighting the differences in motivation, engagement, academic performance, retention, accommodation of learning styles, collaboration, and the potential impact on intrinsic motivation.

Table 1: Comparison Table of Traditional Training, Hands-On Training and Gamification Technique (Omar et al., 2021)

Features	Traditional training	Hands-On Training	Gamification-Technique
High engagement		X	X
User actively engaged		X	X
Fast response to user's mistakes		X	X
Cost effectiveness	X		X
Learning pace accommodate to individuals		X	X
Low physical risk	X		X
Standardized assessments allow users' comparison	X		X
User could apply learning in real world		X	X

The application of gamification in maritime vocabulary acquisition has explicitly shown promising results. Research by Glover (2013) highlighted that gamified learning environments can make vocabulary learning more enjoyable and less intimidating, thereby improving retention rates. Furthermore, gamification can cater to different learning styles and paces, offering personalised learning experiences that traditional methods often fail to provide (Dichev & Dicheva, 2017).

Despite its benefits, the implementation of gamification in education is challenging. Critics argue that over-reliance on extrinsic rewards may undermine intrinsic motivation and lead to superficial learning (Hanus & Fox, 2015). Additionally, the design and execution of gamified learning experiences require careful consideration to ensure they align with educational objectives and outcomes (Seaborn & Fels, 2015). These challenges underscore the need for a nuanced approach to gamification, particularly in specialised fields such as maritime education.

3.0 MARITIME VOCABULARY

3.1 Maritime Vocabulary Acquisition

Maritime vocabulary acquisition is a critical component of training for ratings at Akademi Laut Malaysia. Effective communication is essential for safety, efficiency, and coordination on board ships, and a strong command of maritime terminology is vital (Trenkner, 2009). Traditional methods of vocabulary instruction, often rote memorisation and repetitive drills, may not be sufficient to meet the needs of today's learners (Gregory & Shanahan, 2010).

The dynamic nature of maritime operations requires a vocabulary that is comprehensive and adaptable to different contexts and scenarios. Research indicates that contextualised learning, where vocabulary is taught in relation to specific tasks and situations, can significantly enhance retention and application (Stahl & Nagy, 2007). Gamification, emphasising interactive and immersive learning, can provide contextualised experiences, making vocabulary acquisition more relevant and engaging (Gee, 2008).

Studies have shown that gamified learning can improve both the acquisition and retention of specialised vocabulary. For example, Perry (2015) found that students who used gamified vocabulary learning tools outperformed their peers in traditional learning environments. Using game mechanics such as challenges, quests, and immediate feedback can create a more engaging and effective learning experience (Gee, 2005).

In maritime education, gamification can simulate real-world scenarios where vocabulary is used, reinforcing learning through practice and application. For instance, a gamified module might involve a simulated ship navigation task where students must use appropriate maritime terms to communicate instructions and resolve issues (Reiners & Wood, 2015). Such practical applications can enhance understanding and retention, preparing students for real-life situations (Schwienhorst, 2002).

3.1 Gamification Strategies for Maritime Vocabulary

Implementing gamification in maritime vocabulary acquisition requires a strategic approach that aligns with educational objectives and student needs. Key strategies include using game elements such as points, badges, leaderboards, and narrative-driven quests to enhance motivation and engagement (Zichermann & Cunningham, 2011). Additionally, incorporating collaborative and competitive elements can foster teamwork and peer learning, essential skills in maritime operations (Nah et al., 2014).

One effective strategy is the use of digital flashcards and vocabulary games that provide instant feedback and allow for repeated practice. These tools can be integrated into a larger gamified learning platform that tracks progress and rewards achievements (Wang & Lieberoth, 2016). For example, a digital flashcard app with a points system and leaderboards can motivate students to practice regularly and compete with their peers, enhancing engagement and retention (Hwang & Wu, 2012).

Another strategy is the incorporation of narrative-driven quests that contextualise vocabulary learning within maritime scenarios. These quests can involve tasks such as navigating a virtual ship, communicating with crew members, and responding to emergencies, all of which require the use of specific maritime terms (Correia et al., 2017). By embedding vocabulary learning within meaningful and engaging contexts, students are more likely to retain and apply what they have learned (Gee, 2008).

Additionally, simulations and serious games can provide immersive learning experiences that mimic real-life maritime operations. For instance, a serious game might simulate a ship's bridge, where students must use correct maritime vocabulary to perform tasks and communicate with virtual crew members (Aldrich, 2009). These simulations can offer a safe and controlled environment for practice, enhancing both vocabulary acquisition and operational competence (Prensky, 2005).

4.0 CHALLENGES AND CONSIDERATIONS

While gamification offers significant potential for enhancing maritime vocabulary acquisition, it also presents several challenges and considerations. One major challenge is ensuring that gamified learning experiences are aligned with educational objectives and standards (Plass et al., 2015). With careful design and implementation, gamification may prioritise entertainment over learning, leading to superficial engagement rather than deep understanding (Nicholson, 2012).

Another consideration is the potential for gamification to exacerbate inequalities among students. Not all students may respond equally to gamified learning experiences, and some may feel excluded or demotivated by competitive elements such as leaderboards (Kapp, 2012). It is essential to design gamified activities that are inclusive and accessible to all students, providing multiple pathways to success and recognising diverse forms of achievement (Morschheuser et al., 2018).

Furthermore, the implementation of gamification requires adequate resources and support, including technology infrastructure, training for educators, and ongoing evaluation and refinement (Pereira et al., 2017; Alhammad, M., & Moreno, A. (2018). Institutions must be willing to invest in these resources and provide continuous support to ensure the success of gamified learning initiatives (Deterding, 2012). This includes training educators to effectively design and facilitate gamified learning experiences and using data and feedback to continuously improve these experiences (Kuo & Chuang, 2016).

Finally, there is a need for ongoing research to explore the long-term impacts of gamification on learning outcomes and student motivation. While existing studies provide promising evidence of the benefits of gamification, more research is needed to understand how different game elements and strategies affect learning in diverse contexts and over extended periods (Hamari et al., 2014). This research can inform the development of best practices and guidelines for the effective use of gamification in maritime education (Huang & Soman, 2013).

5.0 CONCLUSION

Gamification presents a promising approach to enhancing maritime vocabulary acquisition for ratings at Akademi Laut Malaysia. By integrating game mechanics into the educational process, gamification can increase motivation, engagement, and learning outcomes, making vocabulary learning more interactive and effective. However, successful implementation requires careful consideration of educational objectives, inclusivity, resource allocation, and ongoing evaluation. With these considerations in mind, gamification can transform maritime education and better prepare students for the challenges of their profession.

Moreover, gamification can address students' diverse learning needs, offering personalised and adaptive learning experiences that traditional methods often fail to provide. The interactive nature of gamified learning environments can make vocabulary acquisition more enjoyable, thus reducing the intimidation often associated with learning complex maritime terminology. By fostering a more engaging and supportive learning atmosphere, gamification can enhance students' confidence and competence in using maritime vocabulary in real-life scenarios.

Future research should continue exploring gamification's long-term impacts on learning outcomes and student motivation in maritime education. Studies should investigate how different game elements and strategies can be optimised to maximise their educational benefits. Additionally, it is essential to develop best practices and guidelines to help educators effectively implement gamification in their teaching. By doing so, we can ensure that gamification enhances vocabulary acquisition and contributes to the overall quality and effectiveness of maritime training programs at Akademi Laut Malaysia.

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