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The Role of Information Systems in Maritime Education and Training: A Critical Review

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Abstract: *The integration of Information Systems (IS) in Maritime Education and Training (MET) is revolutionizing the industry by enhancing educational delivery and operational efficiency. Intensive literature review on the current state of the effectiveness of Information Systems (IS) technologies in enhancing educational outcomes, the barriers hindering their widespread adoption, and emerging trends shaping the future of maritime training was done finding out that IS technologies have demonstrated significant effectiveness in enhancing MET through simulation-based learning and e-learning platforms, offering flexible and accessible training opportunities. However, challenges such as high implementation costs and technological adaptation barriers persist. The literature identified these challenges and emphasized the need for further research to address them. Emerging trends in IS, including Internet of Things (IoT), Blockchain, augmented reality (AR) and virtual reality (VR), were found to present promising opportunities for innovation in MET. In the future, research must be carried out on the investigation of the effectiveness of emerging technologies such as AR, and VR in enhancing maritime training.*

Keywords— Information Systems (IS), Maritime Education and Training (MET), E-learning, Augmented reality (AR), Virtual reality (VR), Blockchain, Technological adaptation,

1. INTRODUCTION

The maritime industry is a critical component of the global economy, facilitating the movement of goods and people across the world's oceans. As this industry evolves, so too does the need for highly skilled and well-trained maritime professionals who can navigate complex operational environments and uphold the highest standards of safety and efficiency. Maritime education and training (MET) are essential for preparing these professionals, encompassing a range of activities from classroom instruction and practical sea-time experience to advanced simulation-based training.

Maritime education and training encompass a wide range of activities designed to equip maritime professionals with the necessary skills and knowledge. Traditionally, MET relied heavily on classroom-based instruction, on-the-job training, and practical sea-time experience. While these methods remain essential, the advent of information systems has introduced new dimensions to MET, offering enhanced learning experiences and addressing some of the limitations of conventional training approaches.

The evolution of Maritime Education and Training (MET) has been influenced by the need for more sophisticated training methodologies to address the complexities of modern maritime operations [1]. This has led to the adoption of information systems, including computer-based training (CBT) [2], and the integration of advanced technologies such as Extended Reality (XR) and computer simulations [3]. The use of Augmented Reality (AR) has also been proposed to enhance the effectiveness of training [4]. These advancements have the potential to significantly improve learning outcomes and better prepare maritime professionals for the challenges of the industry.

The integration of information systems (IS) into Maritime Education and Training (MET) is a fundamental development, enhancing its effectiveness, accessibility, and comprehensiveness [5]. This is particularly important in the digital era, where the maritime industry is rapidly changing due to digitalization and high-level automation [6]. The use of modern technologies such as Extended Reality (XR) and computer simulations, as well as the implementation of academic information systems, can significantly improve the quality of education and training in this sector [7]. However, there is a need for more comprehensive rules that better reflect today's educational needs and progress in the literature [1]. The incorporation of information systems (IS) into maritime education and training has significantly transformed the industry, offering new opportunities to enhance the learning experience, increase accessibility, and improve the competency of maritime professionals [7-10]. Though, this integration is complex and requires a better understanding of the theoretical and practical aspects of IS integration [11]. In the context of mergers and acquisitions (M&A), the challenges of IS integration have been extensively studied, but there is a need for a more comprehensive understanding of these challenges [12]. This suggests that while there is a significant body of research on IS integration, there is still a need for further exploration and consolidation of knowledge in this area [13].

A range of information systems are used in maritime education to enhance learning and practical experience. Learning Management Systems (LMS) such as Moodle and Blackboard are widely used for course management and content delivery [14]. These systems are chosen based on their

flexibility, ease of use, and user-friendliness [15]. Simulation software, including ship bridge and engine room simulators, is also employed to provide practical experience in a controlled environment [16]. Additionally, the use of interactive computer simulations has been found to increase emergency preparedness and reduce the risk of human error in maritime operations [16]. The Automated Identification Systems (AIS) is a comprehensive information system proposed for maritime traffic and commerce, which presents research opportunities for the IS discipline[17].

Emerging immersive technologies, such as VR, AR, and MR, have revolutionized maritime simulations, making them more immersive, compact, and accessible[8]. The application of academic information systems has also played a crucial role in managing data and facilitating education and training activities[7]. Furthermore, the use of modern technologies, including XR, computer simulations, and authentic data, has been shown to enhance the safety and efficiency of vessels in the maritime industry [1]. Lastly, the potential of E-Learning in maritime education and training is being realized, with a focus on understanding the linkage between E-Learning and learning theories[10].

The maritime industry is undergoing significant changes, with digitalization and automation technologies playing a key role in reshaping operations and training [1, 12]. The need for more advanced training tools and methods in Maritime Education and Training (MET) is increasing, driven by the rapid development of digital educational methods and technologies [1]. Simulator-based training, a critical component of MET, is also evolving, with the potential for virtual reality and cloud-based simulators to enhance training practices [12]. However, the application of the STCW 95 convention, while promoting harmonization, also presents challenges in the organization of MET institutions [18]. These developments underline the critical role of information systems in addressing the industry's challenges and aligning with broader trends in digital transformation and globalization.

The adoption of information systems in Maritime Education and Training (MET) is crucial in addressing the industry's evolving needs, including regulatory changes, environmental concerns, and the increasing complexity of maritime operations[1]. Digitalization and automation technologies are driving the need for more advanced training tools and methods in MET [12]. Simulator-based training, a key component of MET, is also undergoing significant technological and pedagogical advancements [12]. The maritime industry is transitioning towards the Fifth Industrial Revolution, with a focus on collaboration between humans and machines, and the role of MET in preparing for this transition is emphasized [19]. However, the adoption of IS in MET also presents challenges, including high initial costs, the need for technical expertise, resistance to change, and cyber security concerns.

In the realm of maritime education and training (MET), the integration of information systems (IS) represents a pivotal yet underexplored area with significant implications for educational effectiveness and industry preparedness. Despite advancements in technology and the widespread adoption of IS in various educational sectors, the maritime industry's unique challenges and requirements necessitate a focused investigation into how these systems are effectively integrated and utilized within MET institutions. Key issues include assessing the true impact of IS technologies such as Learning Management Systems (LMS) and simulation software on enhancing learning outcomes and practical training in maritime environments. Understanding adoption barriers, including financial constraints, technological readiness, and institutional resistance to change, is essential to devising strategies that promote successful implementation and maximize educational benefits. Moreover, the influence of IS on curriculum design, delivery methods, and alignment with industry demands remains a critical concern, as does the need to address cyber security risks associated with the increased digitization of educational processes. Furthermore, exploring opportunities presented by emerging technologies like artificial intelligence (AI) and big data analytics to further optimize IS capabilities in MET represents a promising avenue for future research and innovation. By analyzing current practices, challenges, and innovations, this review aims to provide insights into how IS can be leveraged to enhance the quality of maritime education and align it with the evolving needs of the industry.

The objective of this study was to review the role of information systems (IS) in maritime education and training (MET). Specifically, the study aimed at reviewing the effectiveness of IS such as Learning Management Systems (LMS) and simulation software in enhancing learning outcomes and practical training within MET institutions. It further identified barriers to the adoption of IS in MET, including financial constraints and institutional resistance to technological change and the paper further visited literature on the emerging trends of technologies on MET

2. BACKGROUND AND LITERATURE SURVEY

The literature on the role of information systems in maritime education and training covers various aspects, including the effectiveness of IS technologies, barriers to adoption, and emerging trends. In this section the in depth literature review of the existing situation is visited with the existing gaps present in those visited studies.

2.1 EFFECTIVENESS OF IS TECHNOLOGIES IN MET

The incorporation of Information Systems (IS) technologies in Maritime Education and Training (MET) has been widely recognized for its potential to enhance learning outcomes, improve operational efficiency, and better prepare maritime professionals for the complexities of modern maritime operations. This empirical literature review examines studies that evaluate the effectiveness of various IS technologies, such as Learning Management Systems (LMS), simulation

software, and Automated Identification Systems (AIS), in MET.

2.1.1 Learning Management Systems (LMS)

Learning Management Systems (LMS) such as Moodle and Blackboard are prominent tools in MET for managing courses, delivering content, and assessing student performance.

The use of Learning Management Systems (LMS) in maritime education has been shown to be effective in enhancing the foreign professional competence of future seafarers [20]. These systems, such as the JeLMS, have been found to be highly satisfactory for both instructors and students, with room for improvement in certain areas [21]. E-learning platforms, including LMS, have been proposed as a solution for the continuous training of seafarers, allowing for flexibility and efficiency [22]. However, the legal aspects of applying e-learning in seafarer training, particularly in relation to international and national requirements, need to be carefully considered [23].

A range of studies have highlighted the positive impact of interactive features in Learning Management Systems (LMS) on student engagement and knowledge retention. Swart [24], found that accessing content and completing online assessments in an LMS were significantly correlated with final grades. Oluwajana [25], emphasized the importance of interactivity in the classroom and LMS, with high interactivity in the classroom positively influencing student engagement and satisfaction. Husni [26], further supported this, noting a significant relationship between students' cognitive engagement, motivation, and retention in an LMS. Furda [27] also emphasized the benefits of LMS in engaging students, particularly in high school science classrooms. These findings collectively suggest that the interactive features of LMS can enhance student learning outcomes.

Furthermore, a research conducted by Tubagus [28], stressed the value of Learning Management Systems (LMS) in facilitating blended learning, a method that combines online and face-to-face instruction to enhance learning outcomes. This is supported by Lai [29], who demonstrated the effectiveness of a blended teaching method using an LMS, Moodle, in improving student learning. Dias [30], further emphasized the importance of LMS in blended learning, suggesting that it should be enhanced to cater to distinct learner profiles. Hoić-Božić [31], built on this by proposing a blended learning model that incorporates a range of technologies, including LMS, to support personalized online learning. These studies collectively highlight the role of LMS in blended learning and the need for its continuous improvement to meet the diverse needs of learners.

2.1.2 Simulation Software

Simulation software, including ship bridge and engine room simulators, is a cornerstone of practical training in MET. These tools provide students with hands-on experience in a controlled, risk-free environment, allowing them to develop critical operational skills.

Several researches have consistently shown that ship bridge simulators have a positive impact on maritime students' practical skills. Renganayagalu [32], found that students trained with higher fidelity simulators had higher motivation and perceived skill development. Mangga [33] demonstrated a significant improvement in students' competencies in engine watchkeeping after exposure to engine room simulators. Sellberg [34] emphasized the importance of instructional support in developing professional competencies, with simulators enabling the display and assessment of these skills. Finally, Albayrak [35], highlighted the use of advanced simulators in the development of education and training programs for merchant navy cadets and officers. These studies collectively give emphasis to the fundamental role of ship bridge simulators in enhancing maritime students' practical skills.

The use of engine room simulators have significantly enhanced students' emergency preparedness in maritime operations as discussed by [33, 36]. These simulators, which closely mimic real-life conditions, have been found to improve students' competencies in engine watchkeeping [33], increase ship operational safety standards [37], and enhance knowledge and operational skills [36]. Furthermore, the use of interactive computer simulations in maritime education has been shown to further improve emergency preparedness and reduce the risk of human error [16].

Research on the use of interactive computer simulations in MET consistently shows their positive impact on student engagement and learning. [38], found that these simulations increased student engagement and retention of complex concepts, making learning more effective and enjoyable. This is supported by [39], who emphasized the importance of students' own questioning in their interaction with simulations, and [40], who demonstrated that whole-body interaction with simulations led to significant learning gains and higher engagement. [41], further highlighted the effectiveness of computer simulations in improving student problem-solving ability and conceptual understanding, particularly when used in conjunction with constructivist and Vygotskian perspectives. [42], also highlighted the value of showing the invisible and using analogy in simulations to facilitate students' construction of understanding.

2.1.3 Automated Identification Systems (AIS)

Automated Identification Systems (AIS) are used for real-time tracking and monitoring of vessels, providing valuable data for both operational and educational purposes in MET.

A study conducted by [43], highlighted the potential of AIS in enhancing maritime education and safety. [43], specifically focuses on the integration of real objects into bridge ship-handling simulators, using live AIS data to create more realistic training scenarios. However, [44], raised concerns

about the reliability of AIS data and the potential for human error, emphasizing the need for proper training and supervision. [45], introduces the use of automated machine learning for early identification of at-risk maritime students, suggesting a potential application in AIS training programs. [46], provided a practical perspective, discussing the training and technology onboard ship, including the introduction of AIS and its impact on seafarer competence.

[47], have shown that the incorporation of AIS in simulation training can significantly enhance students' understanding of vessel tracking and collision avoidance strategies, leading to more efficient and safe maritime operations. This finding is supported by [48-50], who found that the use of AIS in ship simulators improved the ability of bridge lookouts to identify potential collisions and take appropriate action. [51] and [52] further underlined the importance of AIS in marine traffic simulation and risk assessment, with the former developing a systematic procedure for collision avoidance behavior analysis and the latter proposing a mathematical model for risk assessment and simulation. [53], provided a broader perspective on the impact of technology, including AIS, on decision-making and safety in marine transportation.

Generally, the visited literatures on the effectiveness of Information Systems (IS) technologies in Maritime Education and Training (MET) indicates substantial benefits in enhancing educational outcomes, improving training efficiency, and increasing the competency of maritime professionals. Studies show that IS technologies, such as simulation-based training, e-learning platforms, and virtual reality (VR), have significantly enriched the learning experience by providing realistic, immersive, and interactive environments. These technologies have been instrumental in facilitating practical skill development, reducing training costs, and offering flexible learning options.

2.2 BARRIERS TO ADOPTION OF INFORMATION SYSTEMS IN MARITIME EDUCATION AND TRAINING (MET)

The adoption of Information Systems (IS) in Maritime Education and Training (MET) has the potential to revolutionize the field by providing advanced tools for simulation, real-time data analysis, and interactive learning. However, despite the evident benefits, several barriers hinder the widespread adoption of these technologies. The review aims to explore the studies on the barriers to IS adoption in MET, categorizing them into technological, organizational, financial, and cultural barriers.

2.2.1 Technological Barriers

Different studies have highlighted the challenges faced by many higher education institutions in integrating information systems technologies (IST). These challenges include limited access to reliable internet, outdated infrastructure, and high costs associated with IST resources [54-56]. The lack of high-speed internet, modern computer systems, and up-to-date software can significantly impede the integration of IST [56]. In addition, factors such as tutors' attitudes, pedagogical knowledge, and the availability of technological resources can influence the effective integration of learning technologies [56, 57]. The slow take-up of technology for the delivery of distance education in maritime education and training (MET) is also a significant challenge [58, 59]. Furthermore, the integration of IST in the classroom is hindered by gaps in ICT knowledge and skills, lack of training, and inadequate support and scaffolding as per [60].

Likewise, integration of new IS technologies with legacy systems presents significant challenges, particularly in data structure adaptation and system functionality [61, 62]. This is further complicated by the need to seamlessly integrate mission-critical legacy systems into modern IT initiatives [63, 64]. The inflexibility of legacy systems and their deep-rootedness in business functionality exacerbate these challenges [65]. Despite these difficulties, successful integration of new technology into legacy systems is possible, as demonstrated in the medical data collection system [66].

Lastly, the potential for cyber threats in maritime education and training (MET) institutions was a significant deterrent, with current programs lacking in cybersecurity education for seafarers [67]. This was a concern across all educational institutions, as the Covid-19 pandemic has increased the vulnerability of e-learning platforms to cyber-attacks [68]. To address these challenges, robust cybersecurity measures are needed, including strong access controls, data encryption, regular software updates, and student training [69]. However, the decentralized nature of many educational networks makes it difficult to implement consistent security measures [70].

2.2.2 Organizational Barriers

Organizational inertia, a critical barrier to technology adoption in higher education, is influenced by a variety of factors. [71, 72], emphasized the need to address the critical mass of faculty users to promote the utility of instructional technology. [73, 74], identified individual adopter categories and various factors that can facilitate or hinder technology adoption. [75], highlighted the role of organizational structure and generational divides as barriers to technology adoption. [76], argued that the lack of faculty interest in eLearning is a symptom of deeper structural and cultural barriers in higher education. These studies collectively stressed the need for a comprehensive approach to addressing organizational inertia and promoting technology adoption in higher education.

Specialized skills and knowledge are required for the successful implementation of IS technologies, and some emphasis is placed on the general IS knowledge, the knowledge of the organization, and the IS-related skills[77, 78]. The current understanding is that IS professionals possess a broad range of competencies, covering skills in technology, business operations, management, and interpersonal areas

[79]. They do report, however, that the absence of alignment among educators and information systems is still a major barrier and that teaching and learning variable–led systems are required [80]. Another major requirement is staff and training in HIS implementation that is oriented toward ongoing training and the needs of the individual in use, with super-users acting as facilitators [81].

According to the study conducted by [82, 83], the effective adoption of IS technologies is contingent on strong leadership and support from top management. This support was influenced by the perceived strategic importance of IT-based resources [84]. The integration of IS across the enterprise was also crucial, with senior IT leadership and strategic information systems planning playing a significant role [85]. Therefore, a clear strategic vision and commitment from top management are essential for successful IS technology adoption.

2.2.3 Financial Barriers

The significant upfront investment required for information system (IS) technologies, particularly in educational institutions, is a major barrier to their successful implementation [86, 87]. This is compounded by the failure to account for indirect and intangible costs, such as training and change management, which are often overlooked in the evaluation process [88]. Limited awareness, poor infrastructure, and budget constraints are also significant barriers to the implementation of ICTs in the education sector [89]. Furthermore, the unique characteristics of higher education institutions, such as their complex management structures, can further complicate the implementation of IS projects [87]. [90], identified financial and time commitments, institutional attitudes, and quality issues as key barriers in the construction industry. In higher education, academic workload is a significant barrier to the implementation of technology-enhanced learning strategies [91]. [92], further highlighted the uneven adoption of digital technologies in higher education, citing factors such as resistance, budget allocations, and leadership issues. These barriers highlight the need for a comprehensive understanding of the costs and challenges associated with IS technologies in educational institutions.

According to [93], the initial cost of adopting new technologies, such as electronic health records (EHRs), can be a significant barrier for institutions. This is particularly relevant for MET institutions, which have high running costs and require significant investments [94]. To address these financial challenges, institutions can consider the use of open educational resources (OER) as a cost-saving measure[95].

The adoption of IS technologies in Maritime Education and Training is fraught with various barriers that need to be addressed to realize the full potential of these innovations. Technological barriers such as infrastructure limitations and cybersecurity concerns, organizational barriers like resistance to change and lack of training and financial barriers including high initial and maintenance costs are all significant. Overcoming these barriers requires a multifaceted approach involving investment in infrastructure, comprehensive training programs, strong leadership and strategic financial planning.

2.3 TRENDS IN INFORMATION SYSTEMS FOR MET

As the maritime industry becomes increasingly complex and technologically advanced, the need for sophisticated training methods and tools has never been greater. In the context of MET, information systems encompass a wide array of technologies, including e-learning platforms, augmented reality (AR), virtual reality (VR), the Internet of Things (IoT), big data analytics, and blockchain technology. These systems are not only revolutionizing how maritime education is delivered but are also addressing the challenges of traditional training methods, such as limited accessibility, high costs, and safety risks associated with practical training.

2.3.1 E-Learning and Online Training Platforms

E-learning platforms provide flexible, accessible, and scalable training solutions. These platforms enable maritime professionals to undertake courses and modules online, facilitating continuous learning and skill development regardless of their location.

E-learning has significantly transformed traditional maritime education by providing flexible and accessible training solutions [10, 96, 97]. It has been found to be particularly effective in the training of seafarers, with the potential to improve learning outcomes and promote internationalization of navigation education[96]. The use of E-learning in maritime education has been further justified by its ability to provide easy access to information and its potential to enhance the learning experience [98]. However, the introduction of E-learning into seafarers' education has also been associated with some challenges, such as the need for optimal integration of maritime and virtual education [97]. This is further supported by [99], who highlighted the potential of e-learning to improve literacy and education in inaccessible areas. In the healthcare sector, e-learning has been shown to provide training and development opportunities, with factors such as success, satisfaction, and availability influencing its effectiveness [100]. The positive attitudes of educators in MET institutions towards e-learning further highlighted its potential in this field [101].

Furthermore, research in maritime education and training (MET) has shown that e-learning platforms can enhance student engagement and learning outcomes, particularly when combined with interactive content and assessments [10, 102]. This is further supported by a comparative study that found a significant increase in learning outcomes and metacognition in an online platform with interactive problem-solving exercises and personalized feedback [103]. The importance of

educator presence, student interactions, and designed connections between online and offline activities in influencing e-learning and blended learning outcomes has also been highlighted [104].

2.3.2 Augmented Reality (AR) and Virtual Reality (VR)

AR and VR technologies create immersive learning environments that enhance the practical skills of maritime trainees. AR overlays digital information onto the real world, while VR provides a fully immersive virtual environment for training.

The use of virtual reality (VR) and augmented reality (AR) in maritime training has been explored in several studies. [8], discussed the potential benefits and limitations of these technologies, highlighting their immersive and cost-effective nature. [105], compared simulator sickness and human performance in VR and AR headsets, finding that VR can lead to higher accuracy and faster response time. [106], further supported the use of VR in safety training, reporting higher perceived enjoyment, motivation, and learning in a VR simulation compared to traditional training methods. [107], introduced the concept of MarSEVR, a technology that integrates finger tracking and hand recognition to enhance user engagement in VR maritime safety training. These studies cooperatively recommend that VR and AR can provide realistic and effective training experiences in the maritime industry.

Different studies have demonstrated the effectiveness of VR training modules in improving spatial awareness and technical skills. For example [108], found that VRLE significantly enhanced the learning of technical skills, particularly in the operation of machines, selection of process parameters, and process planning. [109], further supported this, showing that immersive and collaborative VR environments can improve spatial skills. [110], found that VR can enhance spatial awareness, particularly in the context of history education. [111], provided evidence of the practical benefits of VR integrated training, with participants outperforming those in traditional training methods in a welding context. These studies together highlights the potential of VR training modules in enhancing both spatial awareness and technical skills.

2.3.3 Internet of Things (IoT) and Big Data Analytics

The Internet of Things (IoT) and big data analytics are transforming MET by providing real-time data and insights. IoT devices collect data from various maritime operations, which can be analyzed to improve training programs and operational efficiency.

The integration of IoT devices in training environments has been shown to significantly enhance performance monitoring and data collection. [112] and [113], both highlighted the real-time monitoring and data collection capabilities of IoT in driver training and vocational education, respectively. [112], further emphasized the potential of IoT in military training, where it can provide real-time feedback and create more realistic training environments. In the context of sports and fitness, [114], discussed how IoT can improve performance monitoring and training, particularly through the use of wearables, sensors, and data analytics. These studies jointly stresses the transformative potential of IoT in enhancing training programs.

Big data analytics has also been shown to be a valuable tool in the maritime industry, with the potential to identify trends and patterns in maritime operations [115]. This can inform training needs and improve the relevance of training content, leading to more effective decision-making [115, 116]. However, the use of big data in this context also presents challenges, such as efficient data collection and processing [117]. Despite these challenges, the potential for big data analytics to improve maritime operations is still significant.

2.3.4 Blockchain Technology

Blockchain technology is being explored for its potential to enhance transparency and security in MET.

The use of blockchain for certification and credential verification in the maritime education and training (MET) sector has been extensively explored in the literature. [118] and [119], both highlighted the potential of blockchain to enhance the security and authenticity of digital certificates, with [118], proposing a framework that includes the use of smart contracts for automated authenticity checks. [120], further emphasizes the benefits of decentralization in a blockchain-based certificate verification system, while [121], presents a method for securely storing and verifying digital certificates using blockchain technology. These studies cooperatively emphasize the potential of blockchain to ensure the integrity and authenticity of certificates, thereby reducing fraud and increasing trust in maritime credentials.

Blockchain technology has been identified as a potential tool for enhancing efficiency and accuracy in maritime education and training (MET) [122, 123]. Specifically, it can streamline administrative processes such as record-keeping and tracking of training progress [122]. This is predominantly relevant in the context of the global maritime industry, where blockchain's transformative potential is being recognized [123]. The technology's ability to boost confidence, transparency, and accessibility in public administration is also highlighted [124]. In higher education, blockchain-based solutions are being explored for streamlining diploma verification and securing certificates [125].

The integration of information systems into Maritime Education and Training is transforming the landscape of maritime training. The visited studies consistently demonstrate the positive impacts of these technologies on learning outcomes, engagement, and operational efficiency. E-learning platforms, AR/VR, IoT, big data analytics, and blockchain technology are leading the way in shaping the

future of MET. These emerging trends not only enhance the quality and effectiveness of training but also ensure that maritime professionals are equipped with the skills and knowledge needed for safe and efficient maritime operations in the 21st century. As these technologies continue to evolve, further research is essential to optimize their application and fully realize their potential in maritime education and training.

3. METHODOLOGY

In conducting this critical review, a secondary data methodology was employed. This involved systematically gathering and analyzing existing research from a variety of reputable sources, including peer-reviewed journals, industry reports, and academic theses accessed through databases such as IEEE Xplore, ScienceDirect, SpringerLink, and Google Scholar. The data collection focused on studies that provided empirical data or substantial theoretical insights into the integration and impact of information systems in MET, including areas such as effectiveness of IS technologies in MET, barriers to adoption of IS in MET, and emerging trends of IS for MET.

The collected data underwent a rigorous content analysis process that included thematic coding to identify recurring trends, benefits, challenges, and gaps in the current use of information systems in MET. A comparative analysis was then conducted to synthesize findings across different studies, highlighting commonalities and differences in outcomes, methodologies, and contexts. This approach ensured a comprehensive and balanced synthesis of quantitative and qualitative data, providing a holistic view of how information systems are transforming MET. Triangulation of data from multiple sources, evaluation of source credibility, and chronological analysis were employed to ensure the validity and reliability of the secondary data analysis.

4. OBSERVATION AND DISCUSSION

From the literature survey on the previous section on the role of information systems in Maritime Education and Training (MET), several significant trends and impacts were observed and revealed. Firstly, simulation-based training systems have emerged as a cornerstone in MET. High-fidelity simulators provide realistic, risk-free environments for students to practice maritime operations, significantly enhancing practical skills and decision-making abilities. Most studies indicated that trainees using simulators demonstrated better knowledge retention and skill application compared to traditional training methods. This shift towards simulation-based training stresses the importance of experiential learning in preparing maritime professionals for real-world challenges.

Secondly, e-learning platforms have revolutionized MET by offering flexible and accessible training solutions as many literatures have highlighted that e-learning enables continuous professional development, reduces training costs, and increases accessibility for remote learners. The integration of interactive content and assessments has been shown to improve engagement and learning outcomes. However, some literatures also identified challenges such as the need for robust digital infrastructure and the potential for reduced hands-on experience, which are critical considerations for MET institutions adopting e-learning strategies.

The integration of advanced technologies such as AR/VR, IoT, and blockchain was another prominent trend observed in the review. IoT and machine learning are being utilized to personalize learning experiences and predict training needs, as demonstrated in the literatures. AR and VR technologies offer immersive learning environments that enhance spatial awareness and technical skills. Meanwhile, IoT and big data analytics facilitate real-time data collection and performance monitoring, providing actionable insights to improve training programs. Despite these benefits, the review noted the challenges of high implementation costs and the need for specialized technical expertise.

Lastly, blockchain technology was emerging as a valuable tool in MET for enhancing transparency and security in certification and administrative processes. Further studies have found that blockchain can ensure the integrity of certification, reduce fraud, and streamline administrative tasks. This innovation holds promise for increasing trust in maritime qualifications and improving operational efficiency. However, the adoption of blockchain in MET was still in its early stages, and further research was needed to fully understand its potential and address any implementation barriers.

In conclusion, the review highlights that the integration of information systems in MET is transforming the landscape of maritime training. Simulation-based training, e-learning platforms, AI, AR/VR, IoT, big data analytics, and blockchain technology each offer unique benefits that enhance the effectiveness and accessibility of maritime education. However, challenges such as high costs, the need for technical expertise, and ensuring hands-on experience must be addressed. Future research should focus on optimizing the use of these technologies and exploring their long-term impacts on maritime education and training outcomes.

5. CONCLUSSION AND RECOMMENDATION

The description of the Role of Information Systems in Maritime Education and Training have been clearly provided together with the transformative impact of information systems on the maritime sector. These systems have revolutionized learning and training through advanced simulation tools, e-learning platforms, and virtual reality technologies, providing immersive and practical experiences crucial for maritime professionals. However, the study also highlighted significant challenges, such as the high costs of technology, the need for continuous updates, and specialized training requirements for instructors and students. Despite these obstacles, information systems have improved the efficiency and effectiveness of maritime education, ensuring compliance with international standards and promoting global harmonization.

To maximize the benefits and address the challenges of integrating information systems in maritime education and training, institutions should prioritize investments in cutting-edge technologies and ensure continuous professional development for instructors. Exploring cost management strategies, such as partnerships and resource sharing, can help mitigate financial constraints. Additionally, integrating these technologies seamlessly into the curriculum and maintaining strict compliance with international standards will enhance the overall quality of maritime education. By fostering ongoing research and development, and establishing robust feedback mechanisms, institutions can remain at the forefront of technological innovation, providing high-quality and efficient training programs that meet the evolving demands of the maritime industry.

In the future, further research must be carried out on:

- Investigating the effectiveness of emerging technologies such as artificial intelligence (AI), augmented reality (AR), and virtual reality (VR) in enhancing maritime training.
- Investigating the effectiveness of emerging technologies such as artificial intelligence (AI), augmented reality (AR), and virtual reality (VR) in enhancing simulation-based learning and practical training experiences for maritime students.
- Studying the challenges and barriers faced in the adoption and integration of IS technologies in MET.
- Exploring the potential of IS to support personalized learning paths for maritime students.
- Conducting longitudinal studies to evaluate the long-term impact of IS on the career development and performance of maritime professionals.
- Investigating human factors influencing the adoption and integration of IS in MET.

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