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MARITIME ENGINEERING EDUCATION. A CRUISE SCHOOL ACTIVITY ON BOARD CASE

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Abstract: *The maritime industry's rapid evolution, driven by technological advancements, underscores the imperative for marine engineers to acquire contemporary skills, including firsthand knowledge of onboard ship operations. While modelling and simulation techniques are fundamental in engineering education, direct exposure to operational realities is equally indispensable. Witnessing cargo and passenger handling, alongside onboard workflow organization, fosters an appreciation for precision and quality, particularly at advanced academic levels. This paper analyses prevalent methodologies in educating master's and PhD students in maritime transportation engineering. It introduces a pioneering case study, a collaborative initiative among multiple universities, centred on a cruise school conducted aboard a ship. Throughout the cruise, students received training in diverse logistics and decision-making processes through modelling and simulation methodologies. Additionally, they had the unique opportunity to observe crew operations during loading and unloading activities, both from shore and onboard, augmenting their understanding of real-world maritime practices. Expanding upon this foundation, this educational framework encompasses conventional classroom settings, immersing students within the dynamic maritime ecosystem. Beyond theoretical instruction, the ship serves as a dynamic research platform, facilitating interdisciplinary collaboration and practical experimentation. Furthermore, students engage with industry professionals, attend conferences, and explore career pathways, enriching their academic pursuits and industry acumen. This collaborative educational paradigm equips maritime engineering students with holistic competencies, preparing them to navigate the complex challenges and opportunities within the evolving maritime landscape.*

Keywords: Scientific Cruise, Maritime Education, Port Logistics, Soft Skills, Experiential Education

1. INTRODUCTION

The maritime industry, undergoing rapid evolution driven by technological advancements, requires to marine engineers to possess contemporary skills, including firsthand knowledge of onboard ship operations[1]. As technological advancements continue their rapid ascent, innovations in port operations, logistics, and maritime operations necessitate a new generation of highly-skilled professionals. Moreover, this dynamic environment deals with a lot of challenges, regarding security, planning, and evolving of trade policies and regulations. Addressing these new and ongoing challenges necessitates collaboration between various stakeholders, including government agencies, port authorities, shipping companies, logistics providers, and academic institutions.

Hence, it is clear that the maritime industry is articulated and complex, showing different opportunities and learning sources for seafarers, including students which are exploring this field during their education. As stated by Mallam, the most complicate aspect to consider on the modern ships deals with seafarers' education and training. The have to be adequately prepare to face difficult situations and complex operations[2].

While modelling and simulation techniques are foundational in engineering education, direct exposure to the operational realities at sea is equally indispensable. Directly observing cargo and passenger handling, alongside the intricate organization of onboard workflows, fosters a deep appreciation for precision and quality, particularly for students pursuing advanced academic degrees.

This paper delves into prevalent methodologies employed in educating master's and PhD students in maritime transportation engineering. It introduces a pioneering case study, a collaborative effort among multiple universities, centred on a unique cruise school conducted aboard a ship. Throughout the cruise, students received training in diverse logistics and decision-making processes through both modelling and simulation methodologies. Additionally, they had the distinctive opportunity to observe crew operations during cargo loading and unloading activities, both from the shore and onboard the vessel, significantly augmenting their understanding of real-world maritime practices.

Expanding upon this foundation, this educational framework encompasses conventional classroom settings, immersing students within the dynamic maritime ecosystem. Beyond theoretical instruction, the ship itself serves as a dynamic research platform, facilitating interdisciplinary collaboration and practical experimentation. Furthermore, students engage with industry professionals, attend conferences, and explore career pathways, enriching their academic pursuits and industry acumen.

This collaborative educational paradigm equips maritime engineering students with holistic competencies, preparing them to navigate the complex challenges and opportunities within the evolving maritime landscape.

2. BACKGROUND OF THE RESEARCH

The actual paper can be incorporated in a general framework of the study of the education of seafarers. In general, we can define it as Maritime Education and Training (MET), which includes several activities concerning the maritime and port procedures, that aims at learning processes that equip individuals with the knowledge, skills, and attitudes necessary to operate safely and efficiently in the maritime industry.

Arising from an on-the-job training past, Maritime Education and Training (MET) has evolved alongside the maritime industry's growing complexity. The 1978 STCW Convention established international training standards, and subsequent revisions like the STCW Code in 1995 emphasized demonstrable skills and lifelong learning. This shift benefits early career entrants by providing foundational knowledge and fosters adaptability by facilitating the transfer of seafarer skills across the industry[3].

In the context of maritime education, Belev introduced the Fleet Officers' Seminars (FOS). They function as complementary learning experiences within the maritime industry's framework of lifelong learning. FOS go beyond the required STCW-78/95 Convention competencies, fostering deeper understanding through interaction and exchange between shipowners, officers, and engineers. This collaboration reinforces a shared company culture and creates a sense of community, offering long-term benefits like continuous learning and professional development, similar to how scientific cruises enrich PhD students' educational journeys. Both approaches, while not mandatory, contribute to fostering adaptability and resilience in the ever-evolving maritime landscape[4].

In the modern era, the education process is highly influenced by globalization and technological advancement, which drastically changed the traditional way of teaching[5]. Hence, it is mandatory to introduce the innovations brought by Fourth Industrial Revolution inside the maritime context, to consider all the possible tools and methods that can help in this process. As technology and industry demands evolve, continuous improvement in MET is essential. It ensures a future-proof workforce equipped with the necessary skills to navigate the changing maritime landscape. This adaptability allows seafarers to thrive in new technologies and emerging operational environments.

The core of the education refers to the structure itself, which origins from an *on-the-job training paradigm*[3]: Seafarers gain crucial practical skills and experience by working alongside experienced crew members on operational vessels. This allows them to apply their theoretical knowledge in real-world scenarios and develop practical problem-solving abilities. Moreover, they can update their knowledge and skills through additional training courses, familiarization with new technologies, and adaptation to evolving regulations. This ongoing learning process can be considered an extension of on-the-job training.

The continuous drive for innovation and efficiency in the maritime industry has led to the development of new technologies, specifically in the field of automation, like the Maritime Autonomous Surface Ships (MASS). These are unmanned vessels, equipped with advanced sensors, navigation systems, and decision-making algorithms, which act with a high level of automation. It is clear that, to monitor all the operations on the vessel, seafarers are required to have deep understanding of these complex mechanisms, of data analysis and remote-control systems.

Therefore, introducing the MASS on the maritime industry, there is the need for a new education and training scheme for seafarers, leading to Seafarer 4.0[6]. Moreover, the necessity to revise current educational programs allows to equip seafarers with competencies in artificial intelligence, big data, cybersecurity, and digital systems to manage these advanced ships effectively. It also highlights the shift in seafarers' roles from traditional shipboard tasks to remote operation and control, necessitating a transformation in the training curriculum to meet the demands of this rapidly evolving technological environment. The importance of MASS in the education of seafarers lies in its potential to redefine maritime operations and the essential skills required for future maritime professionals.

Seafarer 4.0 marks a significant departure from previous maritime eras. Unlike the past, where manual labour and traditional navigation prevailed, Seafarer 4.0 operates in a digitalized, automated, and interconnected environment. Key features include the rise of Maritime Autonomous Surface Ships (MASS), which aim to reduce human error and enhance safety. Seafarers now require competencies in artificial intelligence, data analytics, and cybersecurity. Their roles extend beyond shipboard tasks to managing complex systems. In summary, Seafarer 4.0 demands a new breed of maritime professionals who navigate the intersection of technology and maritime operations.

The complex and dynamic nature of maritime industries, encompassing diverse factors like regulations, technology, and global markets, necessitates effective Maritime Education and Training (MET). With a growing demand for skilled seafarers, robust MET programs are crucial for developing competent professionals who can contribute to the safety, efficiency, and sustainability of the maritime sector[7].

Building upon the traditional foundation of classroom instruction and practical experience, Maritime Education and Training (MET) is continuously evolving to meet the needs of the dynamic maritime industry. This evolution embraces advancements in technology, with advanced maritime simulators offering realistic training environments. Emerging technologies like Virtual Reality (VR), Augmented

Reality (AR), and Mixed Reality (MR) are further transforming the learning landscape. VR creates immersive scenarios for practicing shipboard operations and emergency responses, while AR overlays real-time information onto the real world, aiding in tasks like equipment troubleshooting and navigation. MR blends elements of both, facilitating seamless interaction with virtual objects within a real-world setting. These immersive technologies offer exciting possibilities for personalized, mobile, and accessible training, potentially supplementing or replacing traditional simulators and methods. This can provide anywhere, anytime learning, potentially reducing costs and increasing access to simulation training across the industry.

Another possibility which can be followed in the maritime education and training is the game-based learning (GBL), an interesting technique which presents many advantages, including the major curiosity instilled in the students. GBL holds significant potential for enhancing the MET experience. However, the success goes beyond simply incorporating games, since its strength include the simulation of real-world situations and challenges, design specific meta-games. Here, the design phase of the entire learning environment is crucial, since the game has to be as realistic as possible[8].

The relevance of this type of education involves the encouragement of a multifaceted learning environment where various strategies, including images, words, and sounds, contribute to achieving specific learning outcomes, thereby advancing the effectiveness of maritime training[9].

3. DISCUSSION

Starting from the different education methods analysed, the aim of this article is the study of the scientific cruise as a valuable learning environment for PhD students in maritime transportation engineering. The benefits and challenges of scientific cruises are several, focusing on the specific areas of port operations, logistics, and maritime operations. Students play a crucial role in driving innovation and ensuring sustainable growth in this sector. While traditional academic programs provide them with a strong foundation in theory and analytical skills, real-world experience is equally important for developing a comprehensive understanding of the industry's issues.

The central focus of the paper deals with a balanced approach to educating students. While scientific cruises provide invaluable practical experiences, a robust theoretical foundation remains essential (Graduate School of Engineering, Stanford University, 2023). These cruises bridge the gap between theory and practice, enabling students to directly observe the complexities of real-world maritime operations, port logistics, and technological advancements. Through observation and interaction with experienced crew members, students can develop critical thinking and problem-solving skills as they face practical challenges and apply their theoretical knowledge to find solutions[10]. They can also refine crucial soft skills like communication, teamwork, and leadership in a dynamic and demanding environment.

However, it's crucial to acknowledge the limitations of scientific cruises. Their inherent focus on specific aspects of the industry might not encompass the full breadth of knowledge required for a comprehensive understanding. Additionally, the limited resources on board ships might restrict the complexity of learning experiences compared to controlled laboratory setting. To maximize learning outcomes, careful planning is necessary to integrate these experiences seamlessly with the broader academic curriculum[11]. This can involve pre- and post-cruise activities, encouraging critical reflection on observations, and connecting them with theoretical concepts learned in traditional coursework.

Ultimately, scientific cruises should be viewed as complementary learning experiences that enrich the PhD journey. By striking a balance between a strong theoretical foundation built through rigorous academic study and practical exposure gained through scientific cruises and other experiential learning opportunities, universities can equip their students with the holistic knowledge and skill set necessary to become successful professionals in the ever-evolving maritime landscape. This includes fostering a culture of continuous learning and upskilling throughout the PhD program and beyond, encouraging participation in conferences, engaging with industry professionals, and exploring diverse learning resources to stay abreast of advancements and adapt to the changing demands of the industry (Graduate School of Engineering, Stanford University, 2023).

The Benefits of Scientific Cruises for Learning are numerous.

- *Experiential Learning*: As outlined by Kolb[12], this approach emphasizes direct engagement with the learning environment, allowing students to actively test and apply their knowledge in real-world scenarios. Students are exposed to real-world practices, technologies, and challenges faced by maritime professionals, complementing theoretical knowledge gained in classrooms. This can lead to a deeper understanding of the issues related to the maritime operations, and to the development of a solid critical thinking.
- *Interdisciplinary Collaboration*: Cruises facilitate interdisciplinary collaboration[13] between students and professionals from diverse fields within the maritime sector, a key factor very successful in the study of maritime industry. This collaborative environment fosters a holistic understanding of the maritime domain, allowing participants to appreciate the interconnectedness of various aspects of maritime operations.
- *Development of Soft Skills*: Observing and interacting with experienced crew members allows students to develop crucial soft skills like communication, teamwork, problem-solving, and decision-making in a dynamic and demanding environment[14]. Interacting and collaborating with experienced crew members exposes students to the importance of effective communication. Observing how they face complex situations and collaborate efficiently encourages their own teamwork and problem-solving skills. Additionally, the dynamic and demanding environment aboard a scientific cruise fosters independent thinking and decision-making abilities.

The importance of the scientific cruises encompasses the opportunity of learning soft skills: thanks to the observation on the field, it is possible to directly experience all the maritime operation, linked to port operations and logistics. Hence, direct observation plays a critical role in scientific cruises as it allows students to bridge the gap between theoretical knowledge acquired in classrooms and the practical realities of the maritime industry.

- *Port Operations*: Studies[15] highlight the importance of understanding port operations and their role in global supply chains. Scientific cruises provide students with firsthand experience of cargo handling procedures, terminal operations, and the complexities of port logistics. Ports act as crucial gateways for international trade, facilitating the movement of goods between countries and continents. Efficient port operations ensure the smooth flow of goods, minimizing delays and ultimately reducing overall transportation costs within global supply chains.
- *Logistics*: Research by Coyle et al.[16] emphasize the critical role of efficient logistics in the maritime industry. Cruises offer students insights into logistics planning, decision-making processes, and the challenges associated with coordinating diverse transportation modes. Moreover, observing the complexities of coordinating diverse transportation modes, as

various elements like container ships, feeder vessels, trucks, and rail networks, students can understand the general integration for successful cargo delivery. This experience helps them develop a better appreciation of how global trade and maritime operations are intrinsically linked.

- *Maritime Operations*: Studies[17] outline the various aspects of maritime operations, including navigation, and safety procedures. Through practical observation and interaction with crew, students gain a deeper understanding of these critical aspects during the cruise.

Despite the undeniable benefits of scientific cruises, they are not without challenges and limitations. Here we report the most important ones.

- *Limited Resources*: Scientific cruises have limitations in terms of space and resources compared to universities. Adapting to these limitations and creatively utilizing available resources is crucial for effective learning. Instructors and students must work collaboratively to maximize the use of available resources and equipment, potentially employing alternative methods for data collection, analysis, and experimentation. This fosters a problem-solving mindset and resourcefulness, valuable skills for future maritime professionals navigating the ever-present limitations and dynamic demands of the industry.
- *Safety and Regulations*: Stringent regulations, as outlined by the International Maritime Organization (IMO, 2021), govern ship operations, prioritizing the safety of all personnel onboard. This brings a series of restrictions on student access compared to a land-based setting. Certain areas of the vessel, like the engine room or navigation bridge, may be off-limits to students due to safety protocols. Additionally, specific activities, such as operating certain equipment or participating in specific research tasks, may require additional training or certifications. These limitations, while potentially restricting access to certain experiences, are crucial for upholding the highest safety standards for everyone onboard.
- *Integration with Academic Curriculum*: Careful planning by instructors is crucial for maximizing the learning potential of these experiences. The key lies in bridging the gap between the immersive observations and practical applications onboard with the theoretical knowledge acquired in classrooms. This requires instructors to develop strategies for integrating cruise experiences seamlessly into the academic curriculum.

4. CONCLUSIONS AND FUTURE RESEARCH

In conclusion, scientific cruises offer invaluable opportunities for enhancing maritime education and development. These immersive experiences foster experiential learning, interdisciplinary collaboration, and the development of crucial soft skills essential for navigating the complexities of the maritime industry. By providing firsthand exposure to port operations, logistics planning, and various aspects of maritime operations, students gain a deeper understanding of the real-world challenges and practical applications of their theoretical knowledge.

However, acknowledging the limitations of scientific cruises, such as resource constraints, safety regulations, and the need for careful curriculum integration, is crucial. Future research efforts should explore innovative strategies for:

1. Optimize Resource Utilization: Collaborative learning, VR/AR integration, and innovative research methodologies can maximize learning for diverse students on resource-constrained vessels.

2. Enhance Educational Materials: Interactive modules, gamified learning, and real-world case studies can boost engagement and practical skills development.
3. Evaluate Long-Term Impact: Longitudinal studies are needed to assess the lasting impact of scientific cruises on learning, career choices, and professional development.

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[i] Add a brief biography for the Presenter (Corresponding Author) for not more than 4 lines.