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ALTERNATIVE EDUCATIONAL MODELS FOR SUSTAINABLE DEVELOPMENT OF MARITIME EDUCATION

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Abstract. The maritime industry plays a critical role in global trade, contributing significantly to the world economy and facilitating the movement of goods and people across the world. As the industry evolves with technological advancements, climate change, and sustainability demands, maritime education must also adapt. To ensure the long-term sustainability of this sector, it's imperative to develop comprehensive strategies for maritime education. These strategies must focus on fostering a skilled and adaptable workforce while promoting environmental stewardship, technological innovation, and global collaboration.

Traditional educational models, while foundational, may not sufficiently equip students with the skills and knowledge needed to address contemporary challenges. Alternative educational models offer innovative approaches to enhance the sustainability and relevance of maritime education. This study explores several such models and their potential impact on the industry.

*Keywords:*digitalization;maritime education and training (MET);computer-based training(CBT); marine simulators; e-learning

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1. Introduction

A well-educated and trained workforce is necessary for a strong and successful maritime industry;the human factor is the most important element in merchant shipping which directly affects the safety and security at sea (Ziarati, Ziarati&Acar, 2012).In the EMSA analysis of marine accidents for 2014-2022 period is stated that among other contributing factors,51,7% are catalogued as "human action" and 50,8% –as "human behavior", or altogether 80,7% are considered as influenced by human element (EMSA,2023). In another analysis by EMSA, carried out on EMPIC (European Marine Casualty Information Platform) accident data for the period 2011 and 2021, as the main reason (45.1%) for the impact of the human factor is indicated insufficient training, lack of skills and experience (EMSA,2022).

The most important task of maritime education and training is to provide qualified and competent personnel for the shipping industry. The MET is focused on the effective implementation of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention), which outlines global regulations that govern the training, certification and watchkeeping standards of seafarers worldwide.

In an environment of digitalization and rapidly developing technologies, it is more than ever necessary for the teaching, learning and research to be more closely linked with industry needs, i.e. the main aim of MET institutionsshall be to prepare highly skilled personnel to get the helm of the continuously evolving maritime world (Narleva&Gancheva, 2023).

Maritime schools and academies are meeting the challenge by using innovation and old learning to attract, train and retain the industry‘s future workforce.Theyne edtopreparebettertrainedandhighlyskilledprofessionalstodealwiththecomplexitieso fmodernmaritimeoperations andto be ablehandlethem.

2. Analysis

Technology and digitalization are transforming the shipping industry. ‘Smart’ shipsarecomingintoservice, creatingdemandfor a newgenerationofcompetent, highly-skilledmaritimeprofessionals (SkillSeaProject, 2023).

In the EU Blue EconomyReport 2024is ascertainedthat in 2021 almost 380 000 persons were directly employed in the maritime sector (European Commission, 2024). At same time the insufficient number of legally qualified maritime officers for the normal operation of the ships is becoming increasingly apparent. The 2021 Baltic and International Maritime Council(BIMCO) and International Chamber of Maritime (ICS) Seafarer Workforce Report highlights a shortfall of 26,240 ships’ officers certified under the requirements of the STCW Convention (BIMCO&ICS, 2022).

Cognitive methods that can be successfully implemented in a controlled learning virtual platform, for example, are thinking in context, analogy, deduction and induction, decision-making models based on reasoning and evaluation, decision-making under uncertainty, and explicit and implicit decision-making (Atanasova, 2023).

In order for the educational process to meet the new increased demands of the industry, a paradigm shift is needed, modern learning methods must be adapted for a new generation that has a much different perspective on technology and learning styles (Dimitrakieva et al., 2021). Youngerlearnershave a markedaffinityfordigita ltechnologies, theydefinitelypreferinteractiveandgame-likelearningactivitiesoverc onventionalapproaches (Dimitrakiev&Molodchik, 2018).For every teacher today, it is a big challenge how to capture the attention of students in the learning process, which also requires a change in the methodology, so it is always fascinating (Dimitrakiev et al., 2023).

The introduction of alternative and innovative methods across the spectrum of maritime training and education will reflect the pace of change in the maritime sector and the ever-expanding technical capabilities of ship systems.

Below are some novel approaches for the sustainable development of maritime education:

Competency-Based Education (CBE). In the context of maritime education, CBE focuses on critical competencies such as navigation, engineering, safety management, environmental protection, and leadership. CBE ensures that maritime education is directly aligned with industry requirements. By focusing on specific competencies, it prepares students to meet the exact demands of their roles, whether they are navigating a vessel, managing a crew, or ensuring compliance with environmental regulations. As mentioned before, MET is based on STCW Convention requirements, so on completion of their education and approved sea practice the students could be certified after passing exams on the competencies stated in the Convention.Therefore thecurriculum shall be designed around these competencies, ensuring that students acquire the precise skills needed to perform effectively in the maritime industry, as they must demonstrate a thorough understanding and ability to apply these skills.Competency-basedprograms shall emphasize practical, hands-on experience, often through simulations, internships, and on-the-job training. CBE shall encompass continuous assessment and immediate feedback to ensure that students achieve the required competencies. Special attention shall be paid to train the educators and instructors as they play a crucial role in the facilitation and success of CBE, providing personalized support and assessing students' competencies effectively. The last, but not least, the MET institutions should invest in technologies that support the delivery of competency-based education, such as advanced simulators and e-learning platforms, along with seeking support and partnerships with the maritime industry.

Sustainability-Focused Curriculum. As the world increasingly prioritizes sustainability, maritime education must adapt to equip future professionals with the knowledge and skills necessary to lead the industry toward a more sustainable future. A sustainability-focused curriculum is essential for the sustainable development of maritime education, ensuring that the next generation of maritime professionals is prepared to address the environmental challenges of the 21st century.A sustainability-focused curriculum in maritime education should be comprehensive, covering a range of topics that address the environmental, social, and economic dimensions of sustainability. Key components of such a curriculum shall include environmental science and Marine Ecology (e.g.compliance withenvironmental regulations), sustainable maritime operations, sustainability management, ethics and environmental protection.A special place in this curriculumshould be given tothe green technology and innovations, as energy-efficient ship designs, emissions control technologies, and the potential of renewable energy sources as alternative ships propulsion like

wind, ammonia, hydrogen and solar power. Implementing a sustainability-focused curriculum requires a strategic approach that involves curriculum development, faculty training, and industry collaboration.Maritime education has traditionally focused on technical skills and safety, thereforeintegrating sustainability into the curriculum requires a careful balance between maintaining these core areas and introducing the new topics.

Blended Learning. Blended learning merges the strengths of traditional face-to-face instruction with the flexibility and accessibility of online education. In maritime education, this model allows students to engage with course materials both in the classroom and through digital platforms. This approach is particularly beneficial in a global industry where students and professionals often work at sea and cannot consistently attend in-person classes.Blended learning in maritime education includes online course materials, virtual simulations, interactive learning tools (online forums, quizzes, discussion boards, etc.), face-to-face sessions.This combination of online and offline learning will help students to build the skills necessary for maritime careers while accommodating their unique schedules and learning styles.Successfully implementing blended learning in maritime education requires careful planning and the right infrastructure. As maritime education continues to evolve, blended learning will play a crucial role in shaping the future of the industry.

E-Learning. The coercive measures caused by the Covid-19 pandemic gave a significant boost to innovative means and methods of training, such as E-learning (Dimitrakieva et al., 2023).E-learning, which leverages digital platforms for delivering education, presents a sustainable and effective solution for preparing professionals for complexities of maritime industry challenges.Method involves the use of electronic technologies to access educational curriculum outside of a traditional classroom. This is particularly important in the maritime industry, where learners may be geographically dispersed or spend extended periods at sea, making regular attendance in traditional classrooms difficult.There are different components which e-learning in maritime education may include:online courses and modules, learning and training platforms, webinars and online workshops, interactive multimedia (videos, infographics, and interactive exercises).By eliminating the need for physical classrooms and printed materials, e-learning reduces costs for both institutions and students, which can make maritime education more affordable and accessible to a broader audience. Moreover, E-learning platforms often offer personalized learning experiences, allowing students to progress at their own pace and focus on areas where they need improvement, so this individualized approach can lead to better learning outcomes.

Computer-based training and assessment. Among all teaching methods, computer-based education and training (CBT) has emerged as a critical component in preparing seafarers and maritime professionals for the complexities of modern-day shipping.With the growing complicacy of maritime operations, there is an

increasing need for training programs that can provide seafarers with up-to-date knowledge and practical skills in a controlled, risk-free environment.CBT addresses this gap by offering a flexible, scalable, and cost-effective solution that can be easily updated to reflect the latest industry standards and technological developments. It allows maritime professionals to learn at their own pace, revisit challenging topics, and apply theoretical knowledge through simulated scenarios that mimic real-world situations.By allowing trainees to practice in simulated environments, CBT significantly reduces the risk of accidents during training. This not only enhances safety but also instills confidence in seafarers, as they can familiarize themselves with emergency procedures and complex operations without the pressure of real-world consequences. Another benefit of CBT is reducing significant costs related to travel, accommodation, and the use of physical training facilities by providing remote access to training modules, enabling organizations to train more personnel without the need for expensive infrastructure.

An integral part that definitely increases the importance of CBT for maritime education and training iscomputer-based assessment (CBA). Traditionally, assessments in maritime education were conducted through written exams, oral evaluations, and practical demonstrations. However, these methods have limitations, such as subjectivity, logistical challenges, and the difficulty of assessing complex skills in real-time scenarios.The introduction of CBA eliminates these limitations by providing a more standardized, efficient, and flexible approach to assessment. CBA leverages technology to create assessments that are not only more consistent but also more reflective of the real-world demands placed on maritime professionals. CBA is extensively used for testing theoretical knowledge in maritime education and can include multiple-choice questions, short-answer questions, and scenario-based questions that assess a trainee's understanding of key concepts, regulations, and procedures. These tests are often integrated into e-learning platforms, allowing for continuous assessment throughout a course. Additionally, CBA ensures that all candidates are assessed under the same conditions and against the same standards, thus reducing the potential for bias and subjectivity, leading to more fair and reliable assessment outcomes.One of the key advantages of CBA is the ability to provide detailed, personalized feedback. Trainees receive instant feedback on their performance, helping them understand their strengths and areas for improvement.

Simulator training. One of the most significant contributions of CBT to maritime training is the use of simulators. These virtual environments replicate the conditions aboard ships, including navigation, engine room operations, and emergency response scenarios. High-fidelity simulators provide trainees with the opportunity to practice and hone their skills in a realistic but safe setting, reducing the likelihood of human error in actual operations.The introduction of simulators into maritime education and training has revolutionized the way seafarers are trained, offering a highly effective and practical approach to developing the skills

needed to navigate, operate, and manage vessels in a variety of challenging scenarios.Simulators are sophisticated training tools that replicate real-life maritime environments, allowing trainees to experience and manage various operational scenarios in a controlled, risk-free setting. These tools are designed to mimic the physical and operational characteristics of ships, including their navigation systems, engine rooms, and communication interfaces. By providing a realistic training environment, simulators enable seafarers to practice and refine their skills without the inherent risks of live training exercises. There are different types of simulators used in maritime education and training: navigation, Engine Room, cargo handling, communication and GMDSS, Dynamic Positioning (DP), emergency and crisis management simulators, which provide a vast number of features and options. For instance in Nikola Vaptsarov Naval Academy (NVNA), Varna, is situated a Crisis Management Center with simulation of prevailing currents at specific moment, so it can be simulated how a stain from a potential oil spill will spread at some point. One of the most powerful applications of CBA is in simulation-based assessments. Using high-fidelity simulators, trainees can be assessed on their ability to perform complex tasks such as navigation, ship handling, engine operation, and emergency response.There are also possibilities different types of simulators to be interconnected for combined exercise. An example – in NVNA navigation and Engine Room simulators are connected and a simultaneous training of Bridge and Engine Room teams could be carried out, in such way assessing how the entire ship's crew will handle an emergency situation.

Simulator training also places special demands on instructors. Their task is to prepare interesting exercises as close as possible to the real environment. Also, when conducting the exercise itself, they must ensure that the trainees follow the rules of teamwork and cut off any attempt to turn the training into a computer game, which sometime is the trend. Furthermore, their role is extremely important during the debriefing after the exercise – to point out the correct actions as well as the mistakes or wrong decisions made. A positive feature of the simulators is that they allow playback of the video recording and, thus, visualizing the actions taken by the trainees during the training.

The future of simulator-based maritime training is promising, with advancements in technology set to enhance the capabilities and applications of simulators. Virtual reality (VR) and augmented reality (AR) are already being integrated into simulators to provide even more immersive training experiences. These technologies can create highly detailed and interactive environments that could more closely mimic real-life conditions, further improving the effectiveness of simulator training.VR and AR technologies can create immersive learning experiences, such as virtual ship tours, interactive equipment manuals, and simulated emergency situations, providing trainees with a deeper understanding of their working environment.

Implementing AI and IoT. As the industry evolves, there is a growing need to adapt to new technological advancements to ensure sustainability, safety, and efficiency. The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) into maritime education can play a pivotal role in achieving these goals.AI and IoT are transformative technologies that offer new possibilities for maritime education. AI, with its ability to process vast amounts of data and make intelligent decisions, can be applied to various aspects of maritime training, including simulation-based learning, predictive analytics, and personalized education. IoT, on the other hand, connects physical devices and systems, enabling real-time monitoring, data collection, and analysis. Together, these technologies can create a more immersive and interactive learning environment, preparing students for the challenges of the modern maritime industry.One of the most significant applications of AI in maritime education is in the development of advanced training simulations. Traditional maritime training methods often rely on physical simulators, which, while effective, have limitations in terms of scalability and cost. AI-powered simulations can replicate a wide range of real-world scenarios, from navigating complex sea routes to responding to emergencies. These simulations can be tailored to individual learners' needs, providing a more personalized and effective training experience.IoT can further enhance these simulations by integrating data from real-world maritime operations. For example, IoT-enabled sensors on ships can collect data on weather conditions, engine performance, and crew activities. This data can be fed into AI-driven simulators to create realistic training scenarios that closely mirror actual maritime environments. By providing students with hands-on experience in a safe, controlled environment, these technologies can improve their readiness for real-world challenges.IoT devices can be used to monitor the condition of ships, equipment, and crew members in real time. This data can be analyzed using AI algorithms to identify potential safety risks, such as equipment failures or unsafe working conditions, before they lead to accidents. Additionally, AI can be used to analyze historical data to identify patterns and trends, helping educators and industry professionals develop more effective safety protocols and training programs. AI and IoT can play a key role in the area of optimizing the maritime industry by providing tools for monitoring and optimizing energy consumption, reducing emissions, and minimizing waste. For instance, AI-driven analytics can help students understand how to optimize ship routes for fuel efficiency, while IoT sensors can track emissions and provide real-time feedback on environmental performance. By incorporating these technologies into the curriculum, maritime education institutions can prepare students to lead the industry toward a more sustainable future.

Integrating theoretical education and on-board training. Of course, theoretical classes and simulations, however innovative and well-prepared they are, cannot replace the knowledge and experience gained on board a ship. "Sea Training is an integral part of MET and assessed as a part of academic programmes of maritime

education institutions. Today all cadets are obliged to complete successfully at least one year sea training program on board ships to become navigation and marine engineering officers. This training is normally conducted on board suitable merchant vessels and should be assessed by both the ship staff and lecturers of the schools." (Demirel & Bayer, 2016). Theoretical education forms the foundation of maritime training, providing students with the essential knowledge required to understand the complex systems, regulations, and practices that govern maritime operations. This component of MET typically takes place in a classroom or online setting and covers a wide range of subjects.While theoretical education provides the necessary knowledge base, on-board training is where this knowledge is put into practice. On-board training, also known as sea time, is an essential component of MET, offering trainees the opportunity to gain hands-on experience in real maritime environments.The integration of theoretical and on-board training is a key to developing competent and capable maritime professionals. When these two components are effectively combined, they create a comprehensive educational experience that prepares trainees for the requirements of a maritime career.By combining a solid foundation of theoretical knowledge with practical, hands-on experience, MET programs can trainstudents to meet the demands of a work at sea.

Soft skills. While technical skills remain crucial, there is a growing recognition that soft skills are equally essential for the sustainable development of maritime professionals. Softskills–suchascommunication, leadership, teamwork, situationalawareness, decisionmaking, work-loadmanagementandproblem-solving–arecriticalinensuringsafety, efficiency, andcollaborationin a globalizedmaritimeenvironment.A very important part of the training of future maritime professionals is to be prepared to work in a multi-national crew environment, emphasizing respect and tolerance for crew members of other nationalities, cultures and religions.Therefore of utmost importance is a good English language knowledge, which will ensure better incorporation in the crew, where the only official and working language is English.

Lifelong learning. The maritime industry, a cornerstone of global trade and economy, is undergoing rapid changes driven by technological advancements, regulatory shifts, and environmental concerns. In such a dynamic environment, maritime professionals must continually update their skills and knowledge to stay relevant and effective. Lifelong learning, the ongoing pursuit of knowledge and skills throughout an individual's career, is essential for the sustainable development of maritime education.Unlike static education models that provide a one-time qualification, lifelong learning ensures that maritime professionals can keep pace with these changes throughout their careers.They will have to get used to continuous learning and rapid changes in technology. Continuous professional development will play a vital role as seafarers must not only keep up to date but also maintain the credentials needed to prove their qualifications (Biolcheva&Valchev,2023).To foster

a culture of lifelonglearningwithinthemaritimeindustry, educationalinstitutions, employers, andregulatorybodiesmustcollaboratetocreatesupportiveframeworksan dopportunitiesforcontinuouslearning.Lifelong learning is not just an option but a necessity forthesustainabledevelopmentofmaritimeeducation.

3. Conclusions

The article has aimed to highlight the novel approaches and models to be employed in maritime education and training in order to ensure its sustainable development for providing the maritime industry with well educated and trained professionals, capable to cope with new challenges.They offer innovative approaches to developing a skilled, adaptable, and sustainable maritime workforce. Embracing these models is necessary for ensuring the sustainable development of maritime education and, by extension, the industry itself.

Of course, together with all the benefits of these alternative methods, there are lots of drawbacks, which are going to be a subject of future discussions and disputes. However, this does not diminish their importance, as well as the necessity of their proper introduction in the modern training of future marine personnel.On one hand, technological development requires broader interdisciplinary approaches and strengthening the academic character of education, on the other hand, the processes ofautomation and standardization require more professional training (Nikolova et al., 2014). The right and appropriate balance between the academic and professional education will play a vital role for achieving a sustainable maritime education and training.

Regardless of the tasks mentioned above or the methods of teaching used, the main purpose of maritime education and training has never changed and should never change, and that is – the safety of ships and the protection of the environment require highly qualified marine professionals.

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