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Challenges in Teaching Innovative Practices in Logistics and Maritime Transport: Energy Efficiency, Industry 5.0, and Sustainable Fuels

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Abstract: Teaching innovative logistics and maritime transport topics faces significant challenges, including the lack of up-to-date literature, rapidly evolving regulations, and the necessity of bridging the gap between theoretical knowledge and practical applications. This study focuses on analysing the difficulties associated with teaching subjects such as energy efficiency, Industry 5.0, and sustainable practices, emphasising ecological fuels while proposing practical approaches to address these challenges. A hierarchical diagram was developed using a systematic analysis supported by expert discussions and consensus decision-making to identify key issues and corresponding countermeasures. The findings underscore the importance of adaptive teaching materials, practical case studies, and interactive methods in significantly enhancing the learning process. Integrating innovative approaches that align with industry needs is crucial for improving academic preparation and equipping students to meet contemporary professional demands.

Keywords: *Sustainability, Education, Innovation.*

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I. INTRODUCTION

Issues related to implementing new technologies and regulatory requirements in logistics and maritime transport lead to significant challenges for practitioners and academia. These challenges become even more apparent when considering the teaching and knowledge transfer process on both novel and understudied topics in the scientific literature [1], [2]. PhD students combining research with teaching responsibilities for the first time are in a unique position but often face several challenges that affect both the effectiveness of their teaching and the quality of their trainees' training. These difficulties include time management, balancing research and teaching responsibilities, and lack of teaching experience. Current research highlights the need for targeted support and training to develop pedagogical skills among doctoral students to improve their teaching effectiveness and ensure high-quality learning for students by also bridging social gaps [3], [4], [5], [6], [7].

One of the main reasons for these difficulties is the lack of up-to-date sources and practical guidance to reflect current regulations and technologies. Topics such as implementing energy-efficient practices, Industry 5.0 and marine fuel quality are strategically significant for the sector and require a comprehensive understanding of the complex interactions between regulatory requirements, technological solutions and their practical application. These issues become even more critical in the context of sustainable development and the transition to a low-carbon economy, where maritime transport plays a pivotal role.

PhD students who become teachers as part of their training plan face significant challenges arising from the dynamically changing regulatory environment and the need to adapt existing methodologies to new requirements [8], [9], [10], the lack of sufficient up-to-date research in these areas makes it challenging to develop curricula that effectively integrate theoretical and practical aspects. This may lead to gaps in training students who must be prepared to deal with the real challenges in logistics and maritime transport. Current research highlights the need for innovative educational approaches to address these challenges and provide a better link between theory and practice.

The need to develop approaches to address these challenges effectively is clear. This involves analysing existing problems in the teaching process and creating new tools and strategies to facilitate the integration of innovation into teaching. Exploring teaching practices and identifying problems transmitting knowledge on these new topics are

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essential to improving the educational process and creating more effective curricula.

The study aims to analyse the main challenges in teaching topics related to energy efficiency, Industry 5.0, and sustainable practices with a focus on ecological fuels and propose practical approaches for overcoming these challenges while developing guidelines for their integration into the academic process.

II. METHODS

This study applies a methodology to systematically analyse and evaluate the difficulties of teaching innovative logistics and maritime transport topics. The method aims to identify the leading causes of the problems and develop specific approaches to overcome them. The main objective is to propose solutions that facilitate the integration of new regulations and technologies into the learning process and support teachers and learners. The procedure for implementing the method includes the following main stages:

A. Creating a Team of Experts.

A team of PhD students and faculty with expertise in the relevant field is formed to chart the identified issues. The study's main objective is placed at the top level of the hierarchy. The second level encompasses the main activities that influence the achievement of the aim, and the third level identifies the main problems that arise in implementing these activities. The issues are identified through discussions and brainstorming within the expert team.

B. Analysis and Formulation of Countermeasures.

After identifying the main problems, the team conducts further discussions to develop possible countermeasures to overcome them. These countermeasures are recorded at the next level of the hierarchy and may include actions to prevent problems and specific steps to eliminate them after they occur.

C. Assessing the Feasibility of Countermeasures.

At this stage, an analysis of the feasibility of the proposed measures is carried out. The expert team assesses the measures in terms of their effectiveness and the resources needed to implement them. The impact of factors such as limited human and financial resources and the feasibility of practical implementation of the new approaches are also considered. Based on this assessment, the measures are ranked in feasibility and priority.

D. Develop Recommendations

Based on the results of the analysis, recommendations are formulated for improving teaching approaches, emphasising the creation of adaptive methodologies that meet the needs of the contemporary educational and professional environment. This approach aims to create a sustainable basis for solving the identified problems while ensuring the effectiveness and long-term Sustainability of the solutions developed.

III. RESULTS

In the course of the study, the challenges associated with teaching innovative topics in logistics and maritime transport were analysed, mainly highlighting the problems arising from the lack of up-to-date literature, rapidly changing regulatory requirements and the difficulties in integrating theoretical knowledge with practical applications. To address these challenges, a systematic analytical method was employed, involving the creation of a hierarchical diagram that outlined the identified problems and their corresponding countermeasures. The approach allowed a thorough analysis and structuring of the issues that arise in teaching and the formulation of practical solutions.

The main issues hindering the successful teaching of topics such as energy-efficient practices, Industry 5.0 and marine fuel quality were identified through expert teamwork based on brainstorming and consensus decision-making methods. The analysis showed that the lack of adapted teaching materials and limited resources for simulations and hands-on activities significantly hinder the transfer of advanced knowledge. The review of available literature confirmed that these topics remain under-researched, further complicating the process of creating effective curricula.

The results of the study reveal the need to **introduce innovative educational approaches**. These include developing customised and adaptive learning materials, using case studies and simulation platforms, and introducing interactive learning methods to encourage active student participation. In addition, the evaluation of the proposed measures showed a high degree of feasibility, with priority given to solutions that combine efficiency and practicality.

The research highlights the importance of collaboration between academia and industry to create curricula that meet the needs of the modern logistics and maritime sector. The proposed solutions constitute an essential basis for overcoming the identified challenges and better training professionals in these strategically important fields.

The study's findings, derived through a systematic analysis of the pedagogical challenges associated with teaching innovative concepts in logistics and maritime transport, are delineated across several fundamental dimensions:

A. Lack of Up-To-Date Literature and Teaching Resources

The lack of up-to-date teaching materials reflecting the latest regulations and technologies poses a significant challenge for faculty in master's programs, making it difficult to prepare students [11] adequately. This leads to the use of outdated teaching methods and materials that do not comply with current requirements and practices [12], [13], [14]. Studies have shown that using outdated learning resources can lead to low-quality education and unprepared students for the real challenges in industry. Therefore, integrating up-to-date learning materials and technologies is essential to maintain high-quality education and to ensure that students are prepared to meet the challenges of the modern world.

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➢ *Suggested Measures:*

Developing teaching materials based on research and practical examples, using open educational resources, and creating interactive multimedia content to facilitate the visualisation of complex concepts.

B. Difficulties in Integrating New Regulations into the Learning Process

The rapid evolution of regulatory requirements presents significant challenges for students in understanding their practical applications. This dynamic landscape necessitates continuous updates to educational programs to ensure alignment with current industry standards. However, the rapid pace of change often results in a backlog of educational materials, leading to a disconnect between theoretical learning and real-world practices. As noted by Meštrović et al. [15], the maritime industry is undergoing profound transformations due to the integration of autonomous technologies, which in turn require significant adaptations in maritime education to prepare future professionals adequately. Similarly, Bogusławski et al. [16] highlight that the introduction of autonomous shipping will significantly impact maritime operations, necessitating corresponding adjustments in the education and training of seafarers to meet new competency requirements [17]. Consequently, students may find themselves inadequately prepared for the complexities of the modern professional environment, highlighting the critical need for educational institutions to proactively update and adapt their curricula in response to current regulatory and technological advances.

➢ *Proposed Measures.*

Hold seminars with the participation of industry experts, simulate real case studies involving the new regulations, and develop practical exercises aimed at their implementation.

C. Difficulties in Combining Theoretical and Practical Knowledge

Insufficient connection of theoretical material with real examples leads to difficulties for students in understanding and applying knowledge. This mismatch between theory and practice can lead to low motivation and limited understanding of the learning material [18], [19]. Research has shown that integrating practical examples and experiences into learning improves students' understanding and application of knowledge. Therefore, ensuring an appropriate balance between theory and practice is essential for effective learning and preparing students for the real world.

➢ *Suggested Measures:*

Organising study visits to companies in the logistics sector, developing practical assignments related to solving real problems, and setting up mentoring programmes involving industry professionals.

D. Insufficient Student Motivation to Learn Innovative Concepts

Low level of engagement. The low level of engagement among students often stems from the lack of interactive teaching approaches that encourage active participation. Traditional teaching methods focused mainly on lectures and passive absorption of information can lead to reduced motivation and limited understanding of the material [14], [20], [21], [22]. The implementation of interactive methods, such as discussions, simulations and group projects, can significantly increase student engagement by encouraging them to actively participate in the learning process and apply their knowledge in practical contexts. This not only improves understanding and retention of information but also develops critical thinking and problem-solving skills, which are essential in today's educational environment.

➢ *Suggested Measures:*

Introduction of gamification and interactive learning methods, holding logistics problem-solving competitions, and use of case studies that require collaborative teamwork.

E. Lack of Necessary Infrastructure for Simulations and Practical Training

Limited resources in academic institutions. Limited resources in academic institutions, especially the lack of dedicated laboratories and software simulators, pose a serious challenge to the effective teaching of key practical skills [23], [24]. Lack of access to modern technology limits student's opportunities to apply theoretical knowledge in practical situations. This is especially critical in disciplines that require simulations, hands-on experiments, and working with actual data.

➢ *Suggested Measures:*

Collaboration with industrial partners to provide the necessary resources, use of virtual platforms for simulations and organisation of shared training with other academic institutions.

The results of the study show that the application of a combined approach, including the development of innovative learning resources and the introduction of new teaching methods, can significantly facilitate the teaching and learning of modern topics in logistics and maritime transport. The proposed measures have the potential to increase learner engagement, facilitate the integration of new regulations and improve the quality of academic training in the sector.

IV. CONCLUSION

In conclusion, despite the many difficulties associated with teaching innovative topics such as energy-efficient practices, Industry 5.0 and marine fuel quality, the application of systematic analysis and structured evaluation provides practical solutions to overcome these challenges. The results show that the development of adaptable learning materials, the integration of case studies and the introduction of interactive learning methods can significantly improve the quality of academic training and facilitate the integration of new regulations and technologies into the educational process.

In this context, it is advisable to introduce appropriate new teaching methods that provide a better link between theory and practice when their benefits significantly outweigh the risks associated with the limitations in the resources or knowledge available for their application. This will allow the

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development of a sustainable educational foundation to meet the dynamic demands of the modern logistics and maritime sector.

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