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ANDRAGOGICAL APPROACHES TO EDUCATION AND TRAINING: A CRITICAL EVALUATION OF MARITIME EDUCATION IN THE CONTEXT OF INDUSTRY 5.0

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Abstract. The evolution of education and training is shaped by technological, political, economic, and social changes, yet the need for a well-trained workforce remains critical. As a key sector in global transportation, the maritime industry should adapt to Industry 5.0 to equip seafarers with essential skills. Advancements in maritime education and training are vital for industry sustainability and evolving navigation demands.

Literature highlights the benefits of technology-driven training but raises concerns about its impact on core educational values like critical thinking and soft skills. A balanced approach is necessary to integrate digitalization while preserving fundamental learning principles. Maritime curricula should align digital transformation with industry needs, incorporating both andragogical and pedagogical perspectives.8

This study examines Industry 5.0's influence on maritime education, focusing on digitalization and its effect on seafarers' competencies. A PESTEL analysis and curriculum review identify key transformation drivers, emphasizing the role of economic and policy changes. Findings suggest that technology integration should be strategically managed to balance efficiency with educational integrity. Additionally, the curriculum review indicates that frequent changes in the total number of courses, course credits, and elective course offerings over short periods make it challenging to develop a well-structured strategy to meet the requirements of Industry 5.0 seafarers. Ensuring alignment between technological advancements and maritime traditions is crucial for a resilient and future-ready workforce.

Keywords: Maritime Education; Maritime Training; Industry 5.0; Digitalization; MET Curriculum.

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1. INTRODUCTION

As the maritime industry is the backbone of global trade, maritime education plays a crucial role on global sustainability. Recent advancements in technology and changes in the maritime industry are rapidly reshaping the skillsets expected of seafarers (Baldauf et al., 2018). However, the increasing influence of industry requirements on maritime education can sometimes undermine the broader mission of higher education and the traditional concept of a "university." (Phewa, 2021). Further, the changing skillset required by the maritime industry leads to narrowing the gap between training-based education versus university concept.

Courses that focus on soft skills, as well as critical and analytical thinking, are what traditionally distinguish engineers from technicians (Demirel, 2020). Through the widespread the neoliberal models in various sectors and industries, the term "human capital" transformed the concept of university to training centers with blue-collar graduates. Critical and innovative thinking, as well as survival skills, are essential for seafarers which are considered as parts of soft skills. Unfortunately, this attribute is gradually being overshadowed by a heavy emphasis on technical courses.

Furthermore, treating soft skills and humanities-based courses as electives in university programs makes it more difficult to align maritime education with the classical definition of higher education. The application of educational theories in maritime education also presents challenges due to the dominance of engineering-focused courses such as advanced physics and calculus. Although pedagogical and andragogical concepts are evolving with technological developments, instructor-centered, pedagogical teaching remains the prevailing model in maritime faculties. In contrast, adult education ideally requires a more student-centered, motivation-driven approach (Kallis, 2024).

For these reasons, this study aims to explore the implementation of andragogical principles in maritime education and training (MET), and to analyze how maritime curricula have evolved over time in response to technological developments and changes in MET policies. As a final step, a PESTLE analysis will be used to identify and discuss the underlying drivers of these transformations.

2. LITERATURE REVIEW

2.1. Andragogical Approaches to Education and Training

With evolving educational needs, the traditional roles of educators and students are undergoing transformation (Phewa, 2021). Currently, pedagogy-based approaches fall short in meeting the standards of higher education demanded by modern industries. As a result, more learner-centered, motivation-driven, and flexible methods (commonly referred to as andragogical approaches) have gained prominence. The concept of andragogy, introduced by Knowles in the 1980s, is defined as "the art or science of helping adults learn" (Knowles, 1978). This perspective stands in contrast to pedagogy (Chan, 2010). Its foundation lies in internal motivation and the learner's prior experience and need to acquire knowledge (Kallis, 2024).

The six core principles forming the backbone of the andragogical method are: self-concept, experience, readiness to learn, orientation to learning, internal motivation, and the need to know (Chan, 2010; Thompson and Deis, 2004). Often overlooked in higher education, adult learners require greater autonomy and freedom within the educational process. The andragogical perspective is built on cooperation between learners and educators, fostering a more effective academic and professional foundation than passive pedagogical methods.

Some argue that effective learning requires the authority of the educator. However, these claims often overlook the fact that adults differ significantly from children in both psychological and physiological terms (Kallis, 2024). Following the rise of andragogical approaches, various studies have supported this shift. In 2003, Birzer developed a program that transitioned police training from a teacher-centered, behaviorist model to a learner-centered andragogical one (Birzer, 2003; Chan, 2010). Similarly, Bedi applied this framework in medical education, suggesting that andragogical principles have broader applicability than traditional classroom settings (Bedi, 2004; Chan, 2010). Given the characteristics of adult learners and sector-specific needs, pedagogical approaches may be insufficient for both higher and maritime education (Ozuah, 2016; Chan, 2010). Advancements in andragogical theory have led to the emergence of heutagogy, which argues that higher education should prioritize self-directed learning, placing the learner at the center of the educational process (Chacko, 2018). The appeal of this model is likely to grow with continued digital transformation and the expansion of technology-supported learning environments."

2.2. Maritime Education and Training

Nearly 90% of global transportation is conducted via maritime routes; therefore, seafarer qualities such as analytical thinking and adaptability play a vital role in economic sustainability (Phewa, 2021; Sharma, Kim

and Nazir, 2021) MET was developed to meet the need for standardized maritime education due to the complex and multinational nature of the shipping industry (Phewa, 2021). With rapid technological advancements in the maritime sector, the demand for a more responsive and current curriculum has become increasingly critical.

The foundation of MET lies in simulator-based and practice-oriented learning methods. The goal is to equip students with real-life experience for the situations they will encounter onboard (Demirel, 2020). However, emerging trends like digitalization, automation, and sustainability require educational programs that are more agile and better aligned with sectoral developments (Phewa, 2021; Kim et al., 2023).

The age differences among crew and maritime lecturers may also create some barriers for adaptation to new skillsets required for current maritime operations. Older generations often struggle to adapt to technology-driven changes in maritime operations (Phewa, 2021). While institutions may be willing to modernize their curricula, this transition can be challenging for instructors accustomed to traditional methods (Phewa, 2021; Kallis, 2024).

Additionally, there is broad agreement that MET should incorporate more non-technical content focused on soft skills to meet the future demands of shipping (Sharma, Kim and Nazir, 2021; Flin & O'Connor., 2008). These soft skills—such as situational awareness, decision-making, communication, leadership, and workload management—are essential for ensuring safety at sea (Sharma, Kim and Nazir, 2021). Despite being widely acknowledged in academic literature and case studies, many institutions fail to adequately address these skills due to the continued dominance of pedagogy-based instructional strategies (Sharma, Kim and Nazir, 2021).

2.3. Effects of Digitalization and Industry 5.0 in Education

Following the transformations brought about by the Fourth Industrial Revolution in education, it is likely that the Fifth will require deep structural and pedagogical adjustments. Digitalization has significantly altered how information is gathered, transmitted, and consumed over time (Nalupa, 2022). Among the most transformative developments of Industry 4.0 were cyber-physical systems, the Internet of Things, and digital integration. In contrast, Industry 5.0 is expected to emphasize human-centered technologies and sustainability. Consequently, andragogical approaches may become more prominent in higher education institutions to support objectives such as human–machine interaction, critical thinking, and adaptability to industrial advancements (Nalupa, 2022).

With the integration of AR/VR, virtual simulation tools, and AI-supported environments, education may shift toward a more individualized learning experience. In the maritime field, augmented and virtual reality technologies can immerse students in realistic scenarios, supporting experiential learning strategies (Sharma, Kim and Nazir, 2021). However, highly technology-driven classroom may lead to a lack of teamwork skills, which is also considered a soft skill among students. Yet, the limited utilization of AR/VR and AI technologies may facilitate the conceptualization of theoretical information into practical skills.

An important obstacle to revising curricula in terms of technological developments is keeping the pace of subject improvements. This may lead to issues such as underprepared instructors, inadequate infrastructure, and capacity shortages (Nalupa, 2022). Although maritime education and training curriculum should be revised regarding the technological advances, yet the core values of higher education and university should be maintained. Strategically, investing in human capital—especially through technology-oriented education—is vital for sustaining competitiveness in rapidly changing environments Chan, 2010). Adaptation abilities, problem-solving skills, and critical/analytical thinking are highly important components of student-centered education approaches, yet the digital environments and technological classroom might not be able to provide these experiences alone.

2.4. Effects of Industry 5.0 to Maritime Education

Considering the transformations that Industry 4.0 brought, it can be expected that Industry 5.0 will significantly influence the maritime education approaches. The debates on remote control and monitoring technologies and AI-aided navigational systems are changing maritime operations even today. These developments have shifted the role of future seafarers—from carrying out manual operations to supervising systems, analyzing data, and interacting with complex technological interfaces (Sharma, Kim and Nazir, 2021). To this end, not only the educational engineering experiences will be sufficient for future seafarers, but also digital literacy and digital adaptation will be required.

While autonomous systems promise benefits such as reduced emissions, enhanced efficiency, and improved safety, they also pose new risks (Demirel, 2020). Overdependence on automation could lead to

diminished situational awareness and increased vulnerability during emergencies (Sharma, Kim and Nazir, 2021). Although the crew reduction policies are on the agenda with development of automation technologies, the control factor over automation need to be carried out through seafarers which necessities the adaptation of MET curricula considering these expectations.

Moreover, recent studies highlight a substantial skills gap in the current maritime workforce. Many training institutions have been slow to incorporate digital and soft skills into their programs (Sharma, Kim and Nazir, 2021). For instance, a survey by Lloyd's Maritime Academy revealed that over two-thirds of industry professionals recognize a clear disconnect between existing MET outputs and the skill requirements of the future (Sharma, Kim and Nazir, 2021; Demirel, 2020).

To keep up with the sectoral needs and technological improvements, both soft-skill acquisitions process and technological readiness should be integrated to MET concept. This approach aligns with UNESCO's Education 2030 Agenda, which promotes inclusive, equitable, and high-quality education through the use of modern technologies (Nalupa, 2022).

In conclusion, Industry 5.0 necessitates maritime education that is not only technically comprehensive but also adaptive, ethically grounded, and centered around human capabilities. Institutions must prepare learners not only for the demands of today but also for the complex, interdisciplinary challenges that lie ahead (Demirel, 2020)

3. METHOD

This study aims to examine the effects of industrial developments on maritime education. The subject of this study is framed around the expectations of Industry 5 and their reflections on the maritime education and training curriculum. Curriculum analysis is used as the initial phase of the study to trace changes over time. As a case study, the curriculum of Istanbul Technical University Maritime Faculty was selected. The data was collected from the official website of Istanbul Technical University (ITU) (İstanbul Teknik Üniversitesi, n.d.). The previous curriculums were available on the website where the data were gathered. To determine the technology-focused courses the descriptions of courses were evaluated. Similarly, to select the soft skill courses the definition of the term "soft skill" in Cambridge Dictionary was utilized. Regarding the definition, soft skills represent the abilities which enable people to communicate and interact with others and the environment (Cambridge University Press, n.d.). Following this definition, the descriptions of courses were utilized, and soft skill courses were categorized. Only ITU data were considered within this study due to difficulty to gather other education facilities programs and differences among course names and differences in course descriptions. Courses were categorized on website as selective and compulsory, also the campuses of courses were identified as well and the comments under results section were evaluated considering these information. In the second phase, a PESTEL (Aguilar, 1967) analysis is conducted to explore the factors influencing MET and curriculum changes, as well as the impacts of digitalization and industrial developments on maritime education policies.

4. RESULTS

4.1. Curriculum Examination

This section examines the changes over time in the curriculum of ITU's Maritime Transportation Engineering and Marine Engineering departments.

The first table examines the courses in the Maritime Transportation Engineering program related to soft skills and technological interaction with the maritime sector before 2005. No additional courses were identified apart from basic computer literacy (e.g., Computer 101-type) courses. Only one elective course was available under the code GUV 491E, titled 'Organizational Management and Behaviour.'

Table 2 examines the courses in the Marine Engineering program related to soft skills and technological interaction before 2005. Some differences are noted between the Maritime Transportation Engineering

Table 1. Maritime Transportation Engineering Program Course Schedules before 2004-2005 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
GUV 491E	Organizational Management and Behavior	7. semester	Selective

Table 2. Marine Engineering Program Course Schedules before 2004-2005 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
GMI 341E	Automatic Control Systems	5. semester	Compulsory

and machinery departments. No soft skill-related courses were observed in the machinery program. However, the compulsory 'Automatic Control System' course indicates that automation has been on the maritime agenda for more than 25 years.

Table 3 displays the courses between the 2004–2005 and 2009–2010 fall semesters. No compulsory soft skill or humanities courses were observed during this period, except for the elective 'Organizational Management and Behavior' course.

Between the 2004–2005 and 2009–2010 fall semesters, a new course was added to the Marine Engineering program. While the technical drawing course existed in earlier curricula, a computer-aided technical drawing course was introduced during this period. No soft skill or humanities-related courses were observed in the Marine Engineering program during this time.

The Maritime Transportation Engineering Program course schedules between the 2009–2010 and 2013–2014 fall semesters remained the same as the previous two periods. No additional technological or soft skill courses were observed. However, the Marine Engineering program experienced changes between the 2009–2010 and 2011–2012 fall semesters. The traditional technical drawing course was removed and replaced solely with a computer-aided technical drawing course in subsequent semesters.

Between the 2013–2014 and 2017–2018 fall semesters, new soft skills and humanities-related courses were introduced, but all were elective. These courses mainly focused on management topics such as human resources and bridge operations, making it difficult to categorize them strictly as soft skill-based. No new technology-oriented courses were observed in the Maritime Transportation Engineering program during this period.

Between the 2011–2012 and 2017–2018 fall semesters, new soft skill courses were included in the curriculum. However, the asterisked courses were held in other faculties. Since the ITU Maritime Faculty is located approximately two hours away from the main campuses, students were generally reluctant to enroll in these elective courses.

Table 3. Maritime Transportation Engineering Program Course Schedules between 2004-2005/2009-2010 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
GUV 491E	Organizational Management and Behavior	7. semester	Selective

Table 4. Marine Engineering Program Course Schedules between 2004-2005/2009-2010 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
Res 102	Computer-Aided Technical Drawing	2. semester	Compulsory
GMI 341E	Automatic Control Systems	5. semester	Compulsory

Table 5. Maritime Transportation Engineering Program Course Schedules between 2013-2014/2017-2018 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
DFH 212	Human Resources Management in Maritime Sector	4. semester	Selective
DFH 321E	Organizational Management and Behavior in Maritime	5. semester	Selective
DFH 441	Managerial Behavior and Performance in Maritime	7. semester	Selective

Table 6. Marine Engineering Program Course Schedules between 2011-2012 /2017-2018 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
Res 102	Computer-Aided Technical Drawing	2. semester	Compulsory
GMI 341E	Automatic Control Systems	5. semester	Compulsory
ITB 151*	Human Resources Management	8. semester	Selective
ITB 203*	Sociology	8. semester	Selective
ITB 205*	Philosophy	8. semester	Selective
ITB 220*	Psychology	8. semester	Selective

Table 7. Maritime Transportation Engineering Program Course Schedules between 2017-2018/2021-2022 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
DFH 228E	Maritime Psychology	2. semester	Selective
ING 103L*	Mythology	2. semester	Selective
ING 103O*	Psychology	2. semester	Selective
ITB 168E*	Philosophy of Technology	2. semester	Selective
ITB 201E*	Introduction to Humanities & Social Sciences	2. semester	Selective
ITB 203E*	Sociology	2. semester / 8. semester	Selective
DFH 212	Human Resources Management in Maritime Sector	7. semester	Selective
DFH 497E	Org.Mngt &Behavior in Maritime	7. semester	Selective
DFH 228E	Maritime Psychology	8. semester	Selective
DFH 474	Managerial Behavior and Performance in Maritime	8. semester	Selective
ITB 151*	Human Resources Management	8. semester	Selective
ITB 205*	Philosophy	8. semester	Selective
ITB 220*	Psychology	8. semester	Selective

Table 8. Marine Engineering Program Course Schedules between 2017-2018/2021-2022 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
Res 102	Computer-Aided Technical Drawing	1. semester	Compulsory
BIL 100E	Intr.to Prog.Language(PYTHON)	2. semester	Compulsory
BIL 113E	Intr.to Sci& Eng.Comp.(MATLAB)	2. semester	Compulsory
GMI 341E	Automatic Control Systems	5. semester	Compulsory
ITB 151*	Human Resources Management	8. semester	Selective
ITB 203*	Sociology	8. semester	Selective
ITB 205*	Philosophy	8. semester	Selective
ITB 220*	Psychology	8. semester	Selective

Between the 2017–2018 and 2021–2022 fall semesters, new soft skill-related courses were introduced, offered both at the Maritime Faculty and other faculties. However, these courses remained elective. Additionally, no new technology-focused courses were introduced in the Maritime Transportation Engineering program during this period.

During the same period (2017–2018 to 2021–2022), a notable increase in both soft and technological skill-based courses was observed in the Marine Engineering program. Some programming courses became compulsory, while soft skill courses remained elective and continued to be offered at other campuses.

Table 9 presents the most recent curriculum plan for the Maritime Transportation Engineering program at ITU Maritime Faculty. A new elective course on artificial intelligence has been introduced; however, no changes have been made regarding the status of soft skill courses.

Table 10 shows the most recent curriculum of the Marine Engineering program at ITU Maritime Faculty. Some updates include the removal of the PYTHON course and the addition of elective courses on alternative fuel technologies and artificial intelligence applications. There have been no changes in the status of soft skill courses, which are still primarily held at other campuses—making it difficult for Marine Engineering students to attend them.

Table 9. Maritime Transportation Engineering Program Course Schedules After 2021-2022 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
DFH 228E	Maritime Psychology	2. semester / 8. semester	Selective
DFH 474	Managerial Behavior and Performance in Maritime	8. semester	Selective
DFH 497E	Org.Mngt &Behavior in Maritime	8. semester	Selective
ITB 151*	Human Resources Management	8. semester	Selective
ING 103L*	Mythology	2. semester	Selective
ING 103O*	Psychology	2. semester	Selective
ITB 168E*	Philosophy of Technology	2. semester	Selective
ITB 201E*	Introduction to Humanities & Social Sciences	2. semester	Selective
ITB 203*	Sociology	2. semester / 8. semester	Selective
ITB 205*	Philosophy	8. semester	Selective
ITB 220*	Psychology	8. semester	Selective
DFH 212	Human Resources Management in Maritime Sector	7. semester	Selective
MYZ 313E*	Applications of Artificial Intelligence in Maritime	5. semester / 7. semester / 8. semester	Selective

Table 10. Marine Engineering Program Course Schedules after 2021-2022 Fall Semester

Course Code	Course Name	Semester	Selective/Compulsory
GMI 115	Computer-Aided Technical Drawing	2. semester	Compulsory
BIL 113E	Intr.to Sci& Eng.Comp.(MATLAB)	2. semester	Compulsory
GMI 341E	Automatic Control Systems	5. semester	Compulsory
ITB 151*	Human Resources Management	8. semester	Selective
ITB 203*	Sociology	8. semester	Selective
ITB 205*	Philosophy	8. semester	Selective
ITB 220*	Psychology	8. semester	Selective
GMI 477E	Alternative Fuel Technologies	7. semester / 8. semester	Selective
MYZ 313E	Applications of Artificial Intelligence in Maritime	7. semester / 8. semester	Selective

4.2. PESTLE Analysis

PESTLE analysis is an effective way used for many years in various business sectors including maritime industry. The multi-factor structure of PESTLE enables to investigate the roots of the subject problem. Under this section, the reasons of andragogical changes and MET changes will be discussed through PESTLE and the possible requirement for Industry 5.0 seafarers will be evaluated.

Political Factors: The framework of maritime education policies is primarily shaped by the IMO through the STCW Convention. However, the convention evolves over time to reflect developments in maritime business. The last major revisions occurred in the 2010s, and since then, rapid technological changes driven by Industry 4.0—and now Industry 5.0—have emerged. Moreover, national education policies play a crucial role on qualification of maritime education centers. Additionally, national education policies play a crucial role, particularly through governmental investments in areas such as artificial intelligence, cybersecurity, and AR/VR-based learning environments.

Economic Factors: The fundamental problem of digital transitions and their implementations to MET is shaped through the cost of subject transitions. Providing an AI and AR/VR-aided classroom setting and catching the requirements of autonomous

vessels requires great sources not just globally but also national levels. Moreover, as a result of technological changes, the changing supply chain structures and conditions are expected to influence the skillsets of future seafarers.

Social Factors: Age gaps and demographic differences among crew members may pose both beneficial and challenging effects to onboard setting. Whereas the digital literacy of younger generations assists to improve communication and social links among crew with various age groups, these gaps in digital literacy levels may lead to conflicts as well. Furthermore, the multinational nature of navigation may create more gaps, including different digitalization levels of nations. Moreover, a technology-focused working environment might lead to digital fatigue and stress as well as increasing the feeling of loneliness. However, globalization through digitalization may facilitate the female participation to maritime industry.

Technological Factors: Technological improvements are the main reasons for MET transitions. The rise of AI, the expansion of AR/VR in education, and the focus on autonomous vessels all contribute to curriculum transformation. Nonetheless, excessive reliance on automated systems can result in decreased human oversight, leading to potential control errors. Therefore, careful integration of these technologies is essential.

Legal Factors: Current regulations lag behind advancements in autonomous shipping technologies, resulting in legal uncertainties—particularly around MASS (Maritime Autonomous Surface Ships). Cybersecurity has become a critical issue and is expected to grow in importance. Maritime law must evolve to address these emerging concerns. Environmental Factors: Decarbonization and sustainable navigation are leading environmental concerns. Although alternative fuels reduce emissions, they also pose safety risks. While digital tools may enhance monitoring of emissions and waste, Industry 5.0 may introduce new environmental pressures through increased reliance on rare and energy-intensive digital materials.

5. CONCLUSION

Technological developments have gradually influenced MET curricula, as evidenced by the ITU example. However, the educational science aspect appears to be diminishing in favor of a more training-oriented model. While adult learning is most effective when learner motivation and student-centered methods are prioritized, maritime classrooms still largely follow a teacher-centric, pedagogical format. Despite growing consensus on fostering student engagement through technology, some issues require careful consideration. It is evident that critical thinking and soft skills will be essential for future seafarers; yet, in the ITU case, all soft skill-oriented courses remain elective. The increasing emphasis on training over education risks eroding the academic identity of universities. To overcome these issues, maritime educators may be informed or educated regarding andragogical classrooms. The examination systems may be reconsidered, or the training-based curricula may be enriched with more soft skill-based courses. However, to achieve these goals an international and national level policy-making activities are required.

In conclusion, the maritime sector shaped by Industry 5.0 will require seafarers with strong analytical thinking, problem-solving abilities, and interpersonal skills. Regulatory bodies must take concrete steps to integrate such competencies into future curricula.

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