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Future Shipping Operations and Transitioning Maritime Higher Education: An Activity System perspective

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Abstract

With a rapidly evolving shipping industry, and the prospect of autonomous vessels on the horizon, there is a critical need for a workforce equipped with updated skills. However, research indicates that current Maritime Education and Training (MET) falls short in meeting the dynamically evolving requirements of modern and future ship operations. Despite the existence of an international Convention dedicated to MET, marine accidents continue to occur, necessitating a comprehensive examination of the changing landscape of maritime education. MET is currently undergoing a transition to cope with and cater to future shipping requirements. Furthermore, the shipping industry has been known to be reactive and regulation has traditionally been backward looking, legislating for improvements after major disasters. However, the technological changes in Industry 4.0 are rapid and require proactiveness to deal with them. Following the completion of the International Maritime Organization's (IMO) regulatory scoping exercise, the MASS Code is currently under development. Against this background, this paper is timely; it draws upon ethnographic research on the MET process, and advocates for a holistic exploration of evolving MET through the lens of Activity System (AS) analysis. AS provides a theoretical framework to envisage, and comprehensively understand the interconnected components of the maritime higher education AS. This paves the way for a more effective and responsive approach to training the maritime workforce to overcome the challenges posed by Industry 4.0.

Keywords: Activity System (AS), CHAT, STCW, Maritime Education and Training (MET), Maritime Autonomous Surface Ship (MASS), Industry 4.0

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1 Introduction

Transformative technologies are reshaping industries globally in the era of Industry 4.0, to which the maritime domain is no exception. The shipping industry, despite advancements in ship technology and an amplified focus on safety, continues to grapple with incidents and accidents in the 21st century with devastating consequences (EMSA, 2023). This necessitates an inquiry into the evolutionary developments and the challenges within the industry, including scrutinising maritime training. Despite having an international convention dedicated to MET – the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW 1978, 1995, 2010, as amended), the (in)adequacy and efficacy of MET comes under scrutiny in the aftermath of maritime accidents. The occurrence of marine accidents necessitates a critical examination of MET, among other aspects of the industry. A pivotal factor influencing the evolving maritime landscape is the rapid evolution of technology in industry. The modernization of ships incorporating automation, digitalization, Internet of Things (IoT), and artificial intelligence (AI), demands a shift in the competencies and skill sets required for modern and future ship operations, including autonomous ships (Emad, Enshaei, & Ghosh, 2022; Emad & Ghosh, 2023).

The transition from traditional to technologically advanced ships brings forth a pressing need to reevaluate and augment the competencies expected from seafarers. Embracing the concept of Industry 4.0, characterized by digitalization, the fusion of cyber-physical systems, IoT, and the Internet of Systems (IoS), the shipping industry is in a transformative phase. The incorporation

of Industry 4.0 principles is not only altering the operational dynamics but also reshaping the landscape of education and training within the maritime domain. This paper proposes employing Activity System (AS) analysis for it offers a holistic lens to scrutinize the MET higher education AS as it transitions to meet the training requirements of future shipping (Engestrom, 2000; Engeström, Miettinen, & Punamäki-Gitai, 1999). AS enables the examination of the interconnected elements within the system providing insights into the systemic shifts required to meet the demands of the evolving shipping industry. By leveraging AS, this paper aims to investigate the transformation of the maritime higher education and training activity system, aligning it with the emergent needs of modern shipping, thereby bridging the competency gap between the industry requirements and the education and training system (Kataria & Emad, 2022; Narayanan & Emad, 2022).

2 Theoretical Framework

Inspired by Cultural Historical Activity Theory (CHAT), AS analysis helps to holistically envisage and explore the transitioning MET higher education activity system – a comprehensive system that encompasses the interconnected elements essential for cultivating competent seafarers in the shipping industry. MET AS comprises different components, including tools, subject(s), rules, community, and the division of labor, all contributing to the object and the outcome of the AS, the provision of effective and efficient training for oceangoing seafarers. AS enables a holistic study of the interconnected nodes of MET to reveal any inconsistencies and contradictions that would need to be resolved to successfully realise the desired outcome of the AS. The framework helps us understand the connections, the impacts, and the consequences that a change in one node might have on the other inter-connected nodes. AS, can capture both, the transitioning MET AS the way it currently is, and also the direction the system is moving towards, highlighting its affordability. Therefore, this paper recommends AS analysis to comprehensively study the transitioning maritime higher education and training activity system and to identify the probable MET AS for future shipping by extrapolating the trends in the literature and industry.

2.1 MET Higher Education Activity System

The MET Higher Education Activity System is a subset of the MET AS which encompasses both on board training provision and the training provided ashore to seafaring students. The MET higher education activity system only focuses upon shore-based training provided to the seafaring students in a higher education setting. The sharp focus of this paper on the MET higher education AS is justified by noting that this system is largely responsible for the competence development of seafarers, particularly when sea time for training has been reducing over the past two decades and entities have been looking into simulator time in lieu of sea time for training purposes (Nautical Institute, 2020). The MET higher education AS is disproportionately responsible for the competence development of the current workforce. The reasons for this development are beyond the scope of this paper. However, a closer look at the MET higher education AS will help us understand the current situation, evolutionary developments, and contradictions between the elements that need to be identified and addressed.

3 MET Research Study

This paper draws upon the qualitative ethnographic doctoral research of the first author. Research methods for data generation include semi-structured qualitative research interviews, focus groups, and field notes of observations. The data records comprise multimedia records including interview transcripts, pictures, audio, and video recordings, and handwritten field notes. The interviews and focus groups were transcribed verbatim. The data was imported into the Computer Aided Qualitative Data Analysis Software (CAQDAS) NVivo and analysed. The data was coded, and the minor codes were further grouped into major codes, and overarching themes of the research were identified (Braun & Clarke 2012). A major finding of this research was transitioning MET being captured by the AS analysis given in the following section.

4 The Transitioning MET Activity System

The MET higher education AS is currently in transition from traditional MET provision to meeting the needs of modern shopping [7]. Technological advancements in the shipping industry are impacting MET design and delivery and maritime competence development among other facets of the industry. Key drivers of this transition in MET have been the fast-paced adoption of technology, digitalization, and automation in the industry. The disruption caused by the ever-increasing introduction of technology onboard and in MET ashore was further exacerbated by the pandemic (Emad & Kataria, 2022). These rapid evolutionary and disruptive changes in MET necessitate the adoption of a holistic theoretical approach that enables us to understand and map the changes, and also give us an understanding of the future direction the system is heading in. The MET Activity System analysis is up to the task.

The research underpinning this paper reveals that the Tools of the MET higher education AS are predominantly evolving and changing. Consequently, this has far reaching implications for all the interconnected nodes of the system. The transitioning system as it currently stands is captured in figure 1 above. Further mapping the evolutionary changes of the system can give us the possible MET higher education AS for future shipping operations (see section 5, figure 2). The MET higher education AS comprises Tools (primary, secondary, and tertiary) – educational resources (physical and digital), simulators, and technological platforms aimed at imparting theoretical knowledge and practical skills. The subjects are ocean seafaring students and lecturers/instructors. Rules and

regulations govern seafaring studies. The curriculum covers a broad spectrum, from navigation to maritime law, establishing the fundamental knowledge base for aspiring seafarers. Adherence to international regulations such as the STCW convention represents the rules governing training and competency standards. The community includes educators, seafaring students, maritime training institutes, universities, and regulators. The division of labour outlines the roles among maritime educators and seafaring students, all contributing to the cohesive functioning of the system to realise the object of competent oceangoing seafarers, and the overall outcome of effective and efficient training provision for oceangoing seafaring.

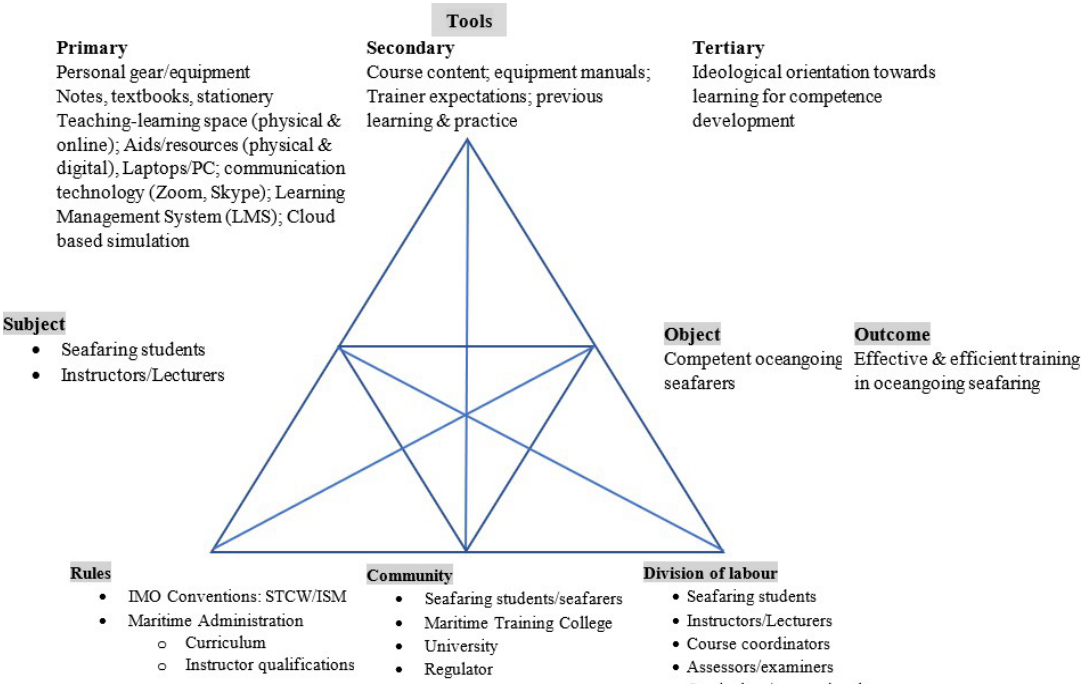

Figure 1: Maritime Education and Training Higher Education Activity System in Transition.
Source: Authors (Adapted from Kataria & Emad, 2022)

The trend of the increasing adoption of technology on board ships necessitated a complementary adoption of technology in MET. Over time, technology was introduced in MET design and delivery, including training via novel simulator technologies. However, due to the pandemic almost overnight the MET provision was moved online, and blended learning was no longer the exception, but the norm. Communication technologies such as Zoom and Skype were utilised to conduct online classes; learning management systems (LMS) were overhauled and students also had remote access to cloud-based simulation technology. Despite the challenges encountered in remote/blended learning, MET provision had changed irrevocably; had been disrupted; and the trend of the increasing incorporation of technology in met design and delivery was here to stay (Kataria & Emad, 2023).

MET higher education AS analysis reveals that the system is in transition and the tools in MET design and delivery have evolved. This evolution of tools impacts all interconnected nodes. The division of labour changed as the lecturers curated and presented content online. The advancements in simulator technologies require the regulators to take note. Mapping the technology and literature trends can give us the probable MET higher education AS for future operations (captured in section 5 below).

5 Envisaging Activity System for Future Ship Operations

Given the swift technological evolution in the maritime industry, the MET higher education activity system must evolve accordingly (Baum-Talmor & Kitada, 2022). The integration of Industry 4.0 principles, including IoT, AI, and automation, necessitates a reassessment of tools, subjects, and the division of labor to align with the changing demands of modern shipping. Understanding and adapting this activity system is vital for MET to produce seafarers equipped with the necessary competencies for the evolving maritime landscape.

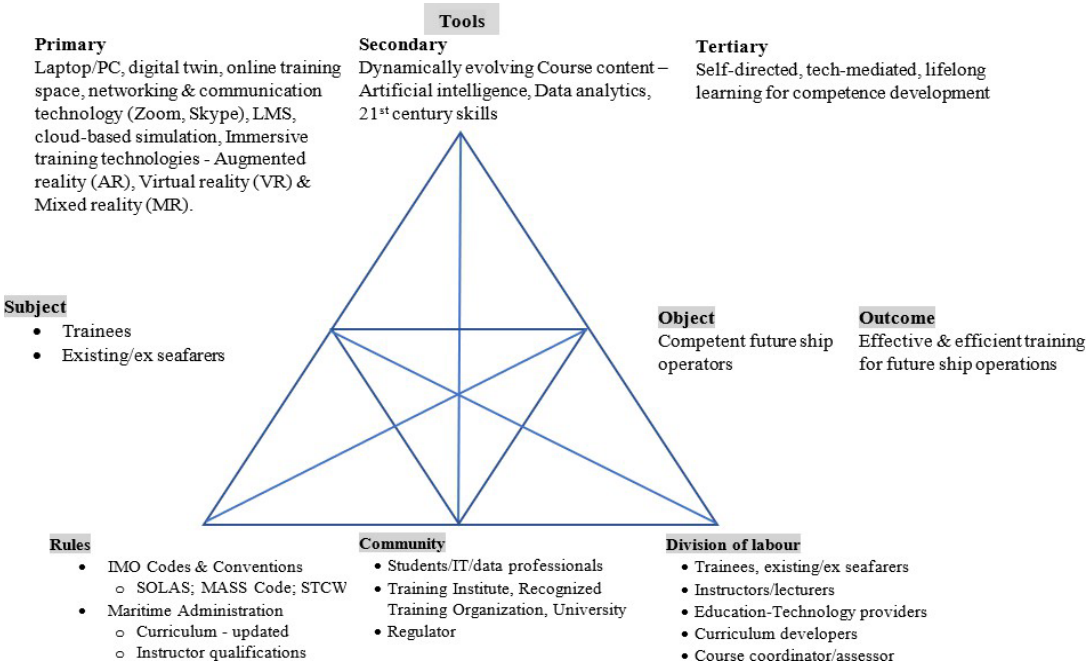

Figure 2: Probable MET Activity System for future ship operations
Source: Authors (Adapted from Kataria & Emad, 2022)

Table 1 below, captures, compares, and contrasts the elements of the MET higher education activity system in transition with those of the possible MET AS for future operations. To conserve space, all of the content within each element of the activity system from the figures (1 and 2) is not captured in the table. The content which is evolving and unique between the two MET activity systems is largely captured. One of the biggest changes can be seen in the tools of the activity system. Immersive training technologies such as Augmented reality (AR), Virtual reality (VR) and Mixed reality (MR), and Digital twin enter the MET system for future operations changing the landscape of maritime training for all time. The manner in which these novel technologies will change the training landscape is beyond the scope of this paper. However, the Activity System approach adopted in this paper enables us to map the developments taking place in the industry leading to the future. It also helps us to gauge the consequent changes in all inter-connected nodes. Needless to say, that all changes in an activity system will have resonances and impact developments down the line in other inter-connected nodes. Another major change is the subject. When seafarers would no longer be working onboard ships, the terminology will change, and the subject will be trainees and ex-seafarers undergoing MET to become operators (Shahbakhsh, Emad, & Cahoon, 2022). The changes to the tools and the subjects impact the rules that will govern the industry. Additionally, the community

expands as a direct consequence of these changes and the division of labour also evolves. See table 1 below for a detailed side by side comparison of the two MET Activity Systems – one in transition and the other looking towards the future.

S.No.	Node		MET AS in transition	Probable MET AS for future operations
1.	**Tools**	***Primary***	Laptop/PC, communication technology, cloud- based simulation, LMS	Digital twin, online training space, networking technology, cloud-based simulation, LMS, immersive training technology – AR, VR, & MR
		Secondary	Course content, equipment manuals, trainer expectations, prior learning & practice	Dynamically evolving course content, Artificial Intelligence, Data analytics, 21st century skills
		Tertiary	Ideological orientation towards learning for competence development	Self-directed technologically mediated lifelong learning for competence development
2.	**Subject**		Seafaring students, lecturers/instructors	Trainees, existing/ex-seafarers to become operators
3.	**Rules**		IMO conventions, maritime administration guidelines, curriculum, instructor qualification	Updated IMO codes & conventions, maritime administration guidelines, curriculum with novel technologies, and instructor qualification
4.	**Community**		Seafaring students, seafarers, maritime training institute, university, regulator	Students, IT/data professionals, training institute, recognized training organization, university, regulator
5.	**Division of labour**		Seafaring students, lecturers/instructors, course coordinators, assessors/examiners, curriculum/ course developers	Trainees, existing/ex seafarers, instructors, assessors, course coordinators, curriculum developers, education-technology providers
6.	**Object**		Competent oceangoing seafarers	Competent future ship operators
7.	**Outcome**		Effective & efficient training in ocean seafaring	Effective & efficient training for future ship operations

Table 1: A comparison of the MET AS in transition with probable MET AS for future ship operations

MASS as a term, is relatively new. It was introduced in the maritime regulatory sphere by the IMO in 2018. The IMO's regulatory scoping exercise for MASS was completed recently in 2021, and the voluntary MASS Code is currently under development. Some estimates suggest that MASS could become a widespread reality for ocean-going vessels within the next couple of decades. This provides us with an opportunity to holistically explore the future training needs of the maritime workforce, and AS analysis is a suitable tool for this task. An understanding of the transitioning and evolving MET higher education AS would enable maritime training institutions to foster an environment conducive to maritime teaching and learning, thereby serving evolving modern and future training needs.

6 Inter-Activity System Interactions

The diversified groups of social actors in the subject(s), community, and division of labour in the probable MET AS for future operations highlight the increasing probability of inter-activity system interactions (Yamagata-Lynch, 2010). For instance, with IT professionals, educational technology

providers, and digital course creators playing an increasing role in the probable future MET AS, over time the interactions will increase with the IT AS and other pertinent ASs. Adjacent and/or related ASs would need to be mapped out to understand the contradictions and identify possible solutions. Figure 3 below highlights the possible adjacent activity systems to enable us to visualize the interactional relationship that may exist between them. Additional research will be required to map all pertinent activity systems. Figure 3 only highlights what this may entail.

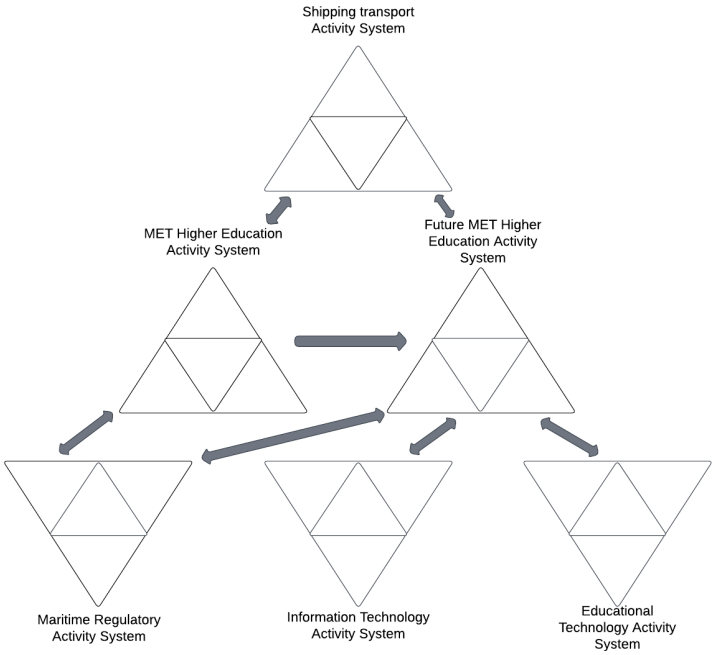

Figure 3: Probable inter-activity system interactions in future MET AS
Source: Authors

7 Conclusion

The AS analysis approach provides us with a comprehensive picture of the current landscape of the MET AS. It also allows us to map the ongoing developments to envisage what the future MET may look like. Doing so facilitates a comparison between the two and we can appreciate the similarities and the dissimilarities between them. The future MET AS also helps us appreciate the possible interactions between it and pertinent activity systems. This helps us to appreciate that AS analysis can help us to zoom in and out for the research focus. We can go deep into each node of the AS, and we can also visualize adjacent and/or pertinent ASs at a glance. An understanding of the transitioning and evolving MET higher education AS would enable maritime training institutions to foster an environment conducive to maritime teaching and learning, thereby serving future training needs.

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