The 22nd IAMUC
Batumi, 21-22 Oct 2022

Proceedings of the
International Association of Maritime Universities Conference

Re-envisioning Maritime Education and Training – Technology facilitated lifelong learning for future ship operators

Aditi Kataria [1, *], Gholam Reza Emad [1]

[1] *Australian Maritime College, University of Tasmania, Australia*
[*] *Corresponding author: aditi.kataria@utas.edu.au; Tel.:* +61-03-000-0000.

Abstract: The increasing introduction of novel and digital technologies on-board ships is changing the landscape of work and the seafaring skill and competencies required to perform the job. The maritime industry currently finds itself in a dynamic evolutionary continuum culminating in the techno-saturated realm of Maritime Autonomous Surface Ships (MASS) of the future. This ongoing transition to future ships foregrounds the continuous and lifelong learning for seafarers to remain relevant as the industry irrevocably progresses and evolves. Meanwhile, the imperative incorporation of new technologies in Maritime Education and Training (MET) during the COVID-19 pandemic disrupted the traditional classroom-based teaching-learning process. Even though this accelerated technology adoption in MET was not free from challenges, it cemented the trend of technologically facilitated maritime blended learning and e-learning. This paper notes the need for lifelong learning in an industry in a flux and the maritime education system undergoing a transition. Seafarer training as we know today cannot serve the needs of future operators who would not be physically present on-board autonomous ships. This paper suggests that the proliferation of on-board technology needs to be complemented by technology in education and training. Furthermore, technology facilitated lifelong learning is imperative for current seafarers to remain relevant.

Keywords: Maritime Education and Training; Lifelong learning; Blended learning; Learning technologies; Maritime Autonomous Surface Ships; Activity System

1. Introduction

The maritime industry currently finds itself in a transition to future shipping that will ultimately culminate in fully autonomous unmanned vessels capable of independent decision making and action (Narayanan & Emad 2020; Sharma, Kim & Nazir 2021. The future ships require trained and competent operators, and seafarers who are relevant to the needs of the changing industry. A complete transition to autonomous ships is still a few decades away as in the beginning it would largely be restricted to resource rich developed nations. Furthermore, due to the lack of a comprehensive international regulation for MASS (STCW 1995, 2010 as amended; IMO 2021), autonomous craft would first ply in national/coastal waters or with bilateral/multilateral agreements between littoral states. It is expected that in the coming decades we could see mixed traffic scenarios wherein manned and unmanned craft operate in the same waters posing challenges beyond the scope of this paper (Baldauf *et al.* 2018). The International Maritime Organisation has identified 4 degrees/stages of MASS operations (IMO 2018, 2019). These stages highlight the increasing introduction of technology on-board ships on one hand, and a decreasing human presence on the other. In stages one and two of MASS, human operators are present on-board, whereas in stages three and four, they will operate and monitor from ashore. We are currently in stage one of MASS operations with other stages under development.

Thus far, MET is playing catch up with developments in the industry; it incorporates technology in curriculum design and delivery as on-board technology increases. The increasing introduction of technology into MET specially when exacerbated by the COVID-19 pandemic disrupted the traditional teaching-learning process tied to the physical brick and mortar spaces of maritime training institutions (Renganayagalu, Mallam & Hernes 2022). Although the process to impart blended learning was already in place at the maritime training establishments for students pursuing distance education, however, the pandemic served as a catalyst to accelerate the move. Communication and network technologies such as Zoom, and Skype were utilised for

lesson delivery during the pandemic. The Learning Management Systems (LMS) were increasingly utilised to share content with the MET students, irreversibly altering the way MET was undertaken before.

This paper captures maritime higher education and training in transition as it evolves to serve the training needs of present-day modern ships. It identifies trends in the literature that are impacting shipping and education to envision what maritime training and education can look like for future shipping. This paper suggests that increasing technology in MET is supportive of the characteristics of lifelong learning and would benefit seafarers remain relevant in the dynamically evolving industry.

2. Literature review – a brief snapshot of MET in the digital age

Lifelong learning is well established in the literature (Laal 2011) and is making inroads in the maritime domain (Sogor 2021). Lifelong learning is a largely voluntary self-initiated, self-motivated undertaking. It indicates a continuous approach to learning and has characteristics that enable an individual to engage in personal and professional growth and development that maybe informal or formal in nature. On the professional front it highlights an adaptable and flexible approach that keeps one sharp, competitive and relevant in a dynamic market (Collins 2009). Lifelong learning can help shape the career trajectory and contribute towards long-term employment of seafarers as marine operators of future ships. Sogor (2021) considers lifelong learning as a useful skill for 21st century mariners in addition to their functional 'core professional skills', 'general transferable skills', and dynamic '21st century skills'. Formal education has been considered less important by firms in a study of current and future competence needs of a maritime cluster; continuous learning is found to be valuable and social and meta competences are regarded important for the future, namely problem solving, flexibility, and management of competence (Kilpi, Solakivi & Kiiski 2021). This indicates a preference for short training/courses for lifelong learning over formal education.

Due to increasing automation and digitalization on-board ships MET is undergoing a transition to meet current and future needs. Gaps between requirements and competences would grow, particularly when technology continues to develop at a faster pace than MET. These technological advancements require the development of appropriate curriculum (Phewa 2021), the cultivation of pertinent digital, information processing skills, and non-technical soft skills in the workforce (de Água *et al.* 2020; Sharma, Kim & Nazir 2021). MET would also need to address and incorporate the rapidly growing blockchain technology into the training regime (Nasaruddin & Emad 2019). Empirical research into MET during the disruptive COVID-19 pandemic has revealed challenges that need to be overcome within technologically assisted distance learning to ensure success. Inequalities in the availability of technology, internet connectivity, as well as techno-pedagogical skills of faculty and students would need to be addressed to reap the benefits (Renganayagalu, Mallam & Hernes 2022). An increasingly important role will be played by novel emerging technologies such as virtual reality, augmented reality, mixed reality, and cloud-based simulation training in MET in the future, however the research is in its nascent stage and widespread adoption is some time away (Mallam, Nazir & Renganayagalu 2019). Maritime simulator training research utilising the sociocultural perspective of Communities of Practise highlights the relevance of computer supported collaborative work to maritime operations in real life (Sharma *et al.* 2019). Computer technology, internet, and shipboard communication equipment play a positive role for mariners to access updated training on-board ships (Belev & Daskalov 2019), however, this is dependent on robust network connections which may not always be available. MASS technologies and operations impact MET. Maritime training would need to cater to each level of MASS. Additionally, a higher level of knowledge and competence would be required in complex MASS technologies such as Cyber-Physical Systems, Integrated Bridge System, algorithms for collision avoidance and path planning, information fusion to accurately perceive environmental information, track control, Internet of Things, big data etc. (Deling *et al.* 2020).

The technological developments in MET point towards the ease in availability, access, convenience, and flexibility that are supportive of lifelong learning. To meet the training challenges of the digital age, MET would benefit from incorporating lifelong learning; inclusive, equitable education, and a shift of focus from formalized learning to creative solutions that capture the 'big picture' (Alop 2019; Alop 2021). Socio-historically situated activity system analysis permits the holistic capture of the MET 'big picture'. An understanding of the constituents reveals that increasing technology in shipping and MET are supportive of tenets of lifelong learning.

3. Activity System

This paper wholistically views education and training in the maritime domain as an activity system positioned under the socio-historical Cultural Historical Activity Theory (CHAT) (Engeström 1999; Yamagata-Lynch 2010). The theoretically well-established activity system triangle facilitates the holistic identification and visualisation of the entire activity system at a glance and its constituent components. It further helps identify the interconnections and challenges/contradictions in the system, if any. The contradictions make us identify the problems that need to be addressed for a successful outcome.

3.1. Transitioning Activity System for MET higher education

The current activity system for maritime higher education has been identified as part of the first author's ethnographic doctoral research on MET (see Figure 1). Components of the activity system evolve over time and help us identify the changes and their impact on other aspects within the activity system and the final outcome. Changes in one activity system also impact other connected activity system(s) and vice-versa. For instance, the outcome of the maritime higher education activity system is competent seafarers. These seafarers and the quality of their competence form a key component of the shipboard activity system (Rajapakse *et al.* 2019) and will impact work and safety on board. An understanding of related activity systems and their connections provide a holistic picture and help us identify the gaps requiring attention.

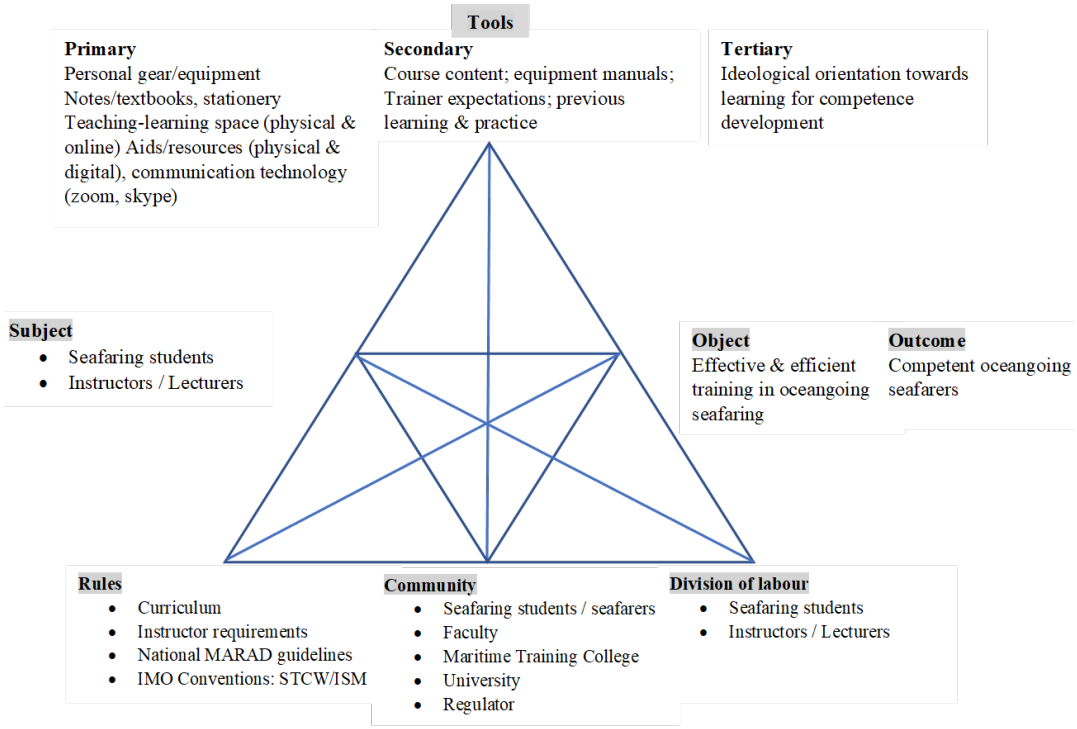

Figure 1. MET Higher Education Activity System – in transition
Source: Adapted from (Emad & Kataria 2022, forthcoming)

The MET higher education activity system is undergoing a transition to keep pace with current and future requirements. The primary drivers of this transition are advancements in the shipboard workplace and the new technologies incorporated into MET design and delivery, particularly in the wake of the COVID-19 pandemic. A sharper understanding of the current MET higher education activity system in transition and the direction in which the industry is heading helps extrapolate and envision the education and training system for future shipping as elucidated in section 3.2 (see figure 2).

3.2. Education and Training Activity System for future ships

An increasing introduction of technology on-board ships has impacted the adoption of technology in MET, curriculum design, development, delivery and the teaching learning experience. An education and training activity system for future shipping helps us holistically visualise the components that cater to future shipping, particularly congruent with stages 3 and 4 of MASS operations (IMO 2021). The subject is no longer limited to

the oceangoing seafarer. Operators, including marine, IT and other shore-based professionals are the subject of this new activity system. Accordingly, the community of stakeholders expands in the activity system of future ships. Changes are also seen in the division of labour in the new activity system, and the increasing policies/regulations the activity system would be subject to. A major change is seen in the tools of the education and training activity system for future ships. Teaching, learning, and training tools would now include novel technologies such as the digital twin of the ship - an exact digital replica of the physical ship on which humans would not be present in stage 4 of MASS (Smogeli 2017). This permits training to be undertaken on the actual digital workplace taking it into the realm of workplace training thereby increasing its effectiveness (Narayanan & Emad 2020). Just as the digital twin frees the workplace from the physical entity, similarly ubiquitous availability of online training and related educational technology frees training from the physical brick and mortar spaces. These developments are conducive of lifelong learning and development.

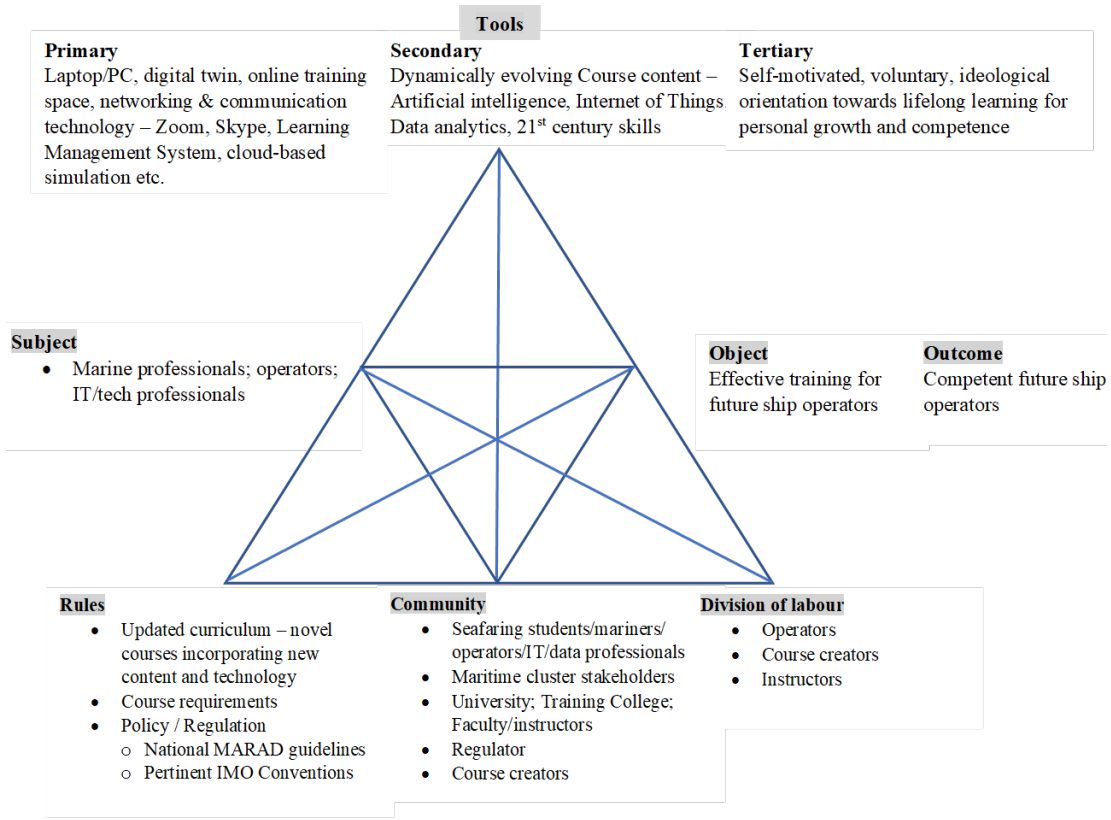

Figure 2. Education and Training Activity System for Future Ships.
Source: Authors

4. Technology facilitated lifelong learning for future ship operators

The education and training activity system for future ships (figure 2) highlights the technological developments in the tools of the activity system. The digital twin of a vessel is a game changer in MET. It permits access to the digital working replica of the physical ship with all of its data (Smogeli 2017). The digital twin *is* the workplace in MASS stages 3 and 4. It frees the workplace from physical confines and makes it available to disparate geographically distributed operators and teams, thereby enabling training and learning to take place in the digital workplace. The digital twin is an industry trend that lends itself well to the pursuance of continuous lifelong learning. The increasing adoption of technology in MET delivery, particularly in the wake of the Covid-19 pandemic made education available beyond the confines of the physical classroom. The developments in cloud-based simulator technology push the boundaries of simulator training to make it widely available to geographically distributed individuals. Though these technological developments are not free from challenges (Kataria & Emad 2022, forthcoming; Renganayagalu, Mallam & Hernes 2022), they indicate growth and are commensurate with the industry findings of their preference for lifelong learning over formalised education (Kilpi, Solakivi & Kiiski 2021). In order to remain relevant for future ship operations, a maritime training establishment would do well to develop training modules and content meeting the needs of MASS

operations across the four stages. Similarly, to remain relevant and employable in the changing maritime industry, a current seafarer would need to engage in continuous lifelong learning supported by technology.

5. Conclusion

Technology facilitated continuous lifelong learning is the way forward in the maritime industry; for seafarers/operators, training establishments, and stakeholders within maritime clusters. This paper captured the maritime higher education activity system in transition utilising activity system analysis. Additionally, the paper utilised the trends identified in the literature – increasing digitalization and on-board automation, and the increasing adoption of technology in MET to extrapolate and depict the education and training activity system for future ships. MET as it currently stands is inadequate for MASS operations. Furthermore, the industry preference for lifelong learning over formalised education will shape training for future MASS operators in the years to come. In the technology rich environment, industry and education stakeholders will increasingly design and provide modular training aligned with MASS requirements to support seafarers/operators along their journey of lifelong learning.

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