



DIGITAL TECHNOLOGY IN MARITIME EDUCATION: ENHANCING PRACTICAL TRAINING AND COMPETENCE OF MARITIME PROFESSIONALS IN TANZANIA

Maulid Shabani Nsalamba 

Dar es Salaam Maritime Institute, Maritime Transport Department,
Sokoine Drive Dar es Salaam, Tanzania
moursasha@gmail.com

Wilfred Johnson Kileo

Dar es Salaam Maritime Institute, Maritime Transport Department,
Sokoine Drive Dar es Salaam, Tanzania
wilfred.kileo@dmi.ac.tz

Abstract

This paper examines the role of digital technology in advancing maritime education in Tanzania, focusing on two dimensions: its influence on maritime practical training and its contribution to the attainment of competent maritime professionals. Using a descriptive research design, data were collected from 113 respondents across key institutions, including the Dar es Salaam Maritime Institute (DMI), Tanzania Ports Authority (TPA), Tanzania Shipping Agency Corporation (TASAC), and TEMESA. Findings indicate that digital technology significantly improves the replication of real-world scenarios, reduces training costs, accelerates the transfer of theoretical knowledge to practical skills, and fosters student engagement. Moreover, it enhances problem-solving capacity, critical thinking, and retention of complex maritime concepts among trainees. The study concludes that digital technology plays a transformative role in producing competent maritime professionals aligned with international standards, and it recommends increased investment in simulation equipment and digital resources to strengthen maritime education in Tanzania.

Keywords: Digital Technology, Maritime Education, Practical Training, Competence, Tanzania, Simulation, Professional Skills

INTRODUCTION

Maritime Education and Training (MET) is crucial for maintaining a safe, efficient, and environmentally responsible shipping industry, which facilitates approximately 90% of global trade (Kim et al., 2021; IMO, 2019). High-quality MET ensures that seafarers acquire the specialised knowledge, technical skills, and professional competencies required to operate increasingly sophisticated vessels and navigate complex maritime environments (Boonadir, 2022; Yildirim et al., 2022). With technological innovations such as automation, artificial intelligence (AI), big data analytics, virtual reality (VR), and augmented reality (AR) becoming integral to maritime operations, the need for continuous professional development has never been more critical (Narayanan & Emad, 2022; Nhleko & Yamkela, 2022). Globally, investment in MET helps reduce human-error-related accidents, responsible for 80–90% of maritime incidents, and ensures compliance with STCW standards (Koh et al., 2021; Baylon, 2016).

Africa, endowed with vast navigable waters including the Indian Ocean, major rivers, and large lakes such as Lake Victoria, has immense potential in maritime trade and transport (Shan et al., 2018; Sutalo et al., 2021). However, the continent faces challenges in producing a skilled maritime workforce that meets international standards. While countries such as South Africa have relatively advanced MET infrastructure, many East African nations lag due to limited institutional capacity, inadequate training equipment, and insufficient integration of digital technologies (Sharma, 2021; Wiig, 2019). Strengthening MET in Africa is therefore crucial not only for improving the safety, efficiency, and competitiveness of its maritime industry but also for enhancing regional trade and global participation in the maritime economy (Anabia-Tiah, 2022).

Tanzania, located along the Indian Ocean and Lake Victoria, faces challenges in maritime human capacity due to a few MET institutions and limited modern training equipment. Many seafarers seek overseas training, which can affect international recognition and employability. Integrating digital technologies such as simulators, VR, AR, and automation into local MET programs can enhance skills, reduce costs, and align professionals with global standards, making it essential for national expertise, economic growth, and participation in the global maritime workforce (Mkpandiok & Ukpai, 2017; Edirisinghe et al., 2016; Sharma, 2021; Wiig, 2019; Nhleko & Yamkela, 2022; Narayanan & Emad, 2022; Boonadir, 2022).

Globally, in Africa, and in Tanzania, MET is indispensable for producing competent professionals capable of navigating evolving technological, regulatory, and operational challenges (Yildirim et al., 2022; Sutalo et al., 2021). Investment in MET ensures safer shipping operations, reduces human error, promotes economic growth, and enhances global competitiveness. For Tanzania and the broader African region, enhancing MET through digitalisation and modern training methods is key to bridging the current skills gap, fostering

international recognition of professionals, and maximising the benefits of maritime trade (Kim et al., 2021; Narayanan & Emad, 2022).

Tanzania has actively pursued the adoption of digital technologies in maritime education and training to comply with international conventions such as STCW and IMO standards (Kiplimo & Ikua, 2016). The country has joined key international maritime organisations, ratified relevant conventions, and adhered to SOLAS requirements to ensure proper training, certification, and watchkeeping for seafarers. Domestically, initiatives such as the Maritime Education and Training Fund (METFUND, 2012) and the establishment of the Tanzania Shipping Agency (TASAC, 2017) aim to monitor certification and enhance professional standards. Despite these efforts, local MET institutions still face challenges in producing globally competitive professionals due to gaps in digital technology integration, institutional capacity, and practical implementation, highlighting the need for further improvement to meet international benchmarks (Anabia-Tiah, 2022; Nhleko & Yamkela, 2022; Mkpandioke & Ukpai, 2017).

Despite Tanzania's efforts to comply with STCW and IMO standards, a persistent gap remains due to limited modern training equipment, underdeveloped digital integration in MET institutions, and insufficient policy frameworks to support the effective adoption of digital technologies. While initiatives such as the Maritime Education and Training Fund (METFUND) and the Tanzania Shipping Agency (TASAC) aim to enhance training quality and professional certification, current policies do not fully address the integration of advanced digital tools or the development of globally competitive competencies.

This policy gap limits the ability of local MET institutions to produce maritime professionals who meet international standards, highlighting the need for strengthened regulatory guidance and strategic investment in digital infrastructure (Sharma, 2021; Wiig, 2019; Nhleko & Yamkela, 2022). The study aims to assess the role of digital technology in enhancing practical training and competency development of maritime professionals in Tanzania

LITERATURE REVIEW

Theoretical Review

The Cultural-Historical Activity Theory (CHAT) was developed by Lev Vygotsky in the 1920s–1930s, focusing on how human learning and development are mediated by cultural tools and social interactions. Yrjö Engeström later expanded this framework (1987–2001) to emphasise activity systems, including the interactions among subjects, tools, rules, community, and division of labour, and to analyse contradictions that drive learning and organisational change.

In the context of this study, CHAT is relevant because it provides a lens to examine how digital technologies (tools) mediate the activities of maritime education and training (MET) institutions in Tanzania. It helps explore how these tools interact with instructors (subjects), trainees, institutional policies (rules), and the broader maritime community to shape the acquisition of practical skills and competencies. By applying CHAT, the study can identify gaps, challenges, and opportunities in the integration of digital technologies in MET, linking the socio-cultural, institutional, and technological dimensions to the development of world-class maritime professionals (Yildirim et al., 2022).

Empirical Review

Global empirical studies have demonstrated the effectiveness of simulation, virtual reality (VR), and digital tools in enhancing maritime education and training (MET) across various countries, including Australia, Croatia, and China.

Research by Miyusov et al. (2022) conducted a pedagogical experiment at the National University Odessa Maritime Academy, training 115 navigator cadets using a VR-based 'Wall wash test procedure on a chemical tanker.' The results showed a 25.93% improvement in the quality of mastering new knowledge, demonstrating the effectiveness of VR in enhancing practical training and safety awareness.

A study by Bačnar, Barić, and Ogrizović (2025) applied the Technology Acceptance Model to assess maritime engineering students' intentions to adopt a head-mounted display (HMD) VR engine room simulator. The study found that perceived usefulness was the primary determinant influencing students' behavioural intention to use the simulator as a training tool. The Australian Maritime & Fisheries Academy (AMFA) has integrated VR technology into MET through partnerships with Morild Virtual Reality simulators. These immersive systems enable trainees to engage in realistic maritime scenarios, enhancing practical skills and reducing training costs.

Empirical studies in Africa indicate that the integration of digital tools, simulation, and virtual reality (VR) in maritime education and training (MET) is still limited but evolving. In South Africa, Nhleko (2022, 2025) highlighted the importance of digital tools for enhancing sustainability-focused curricula and developing competencies aligned with modern maritime operations. In Nigeria, Mkpandioke and Ukpai (2017) emphasised the role of technology in improving training quality and meeting international standards. In Tanzania, Mayagilo (1997) provided foundational insights into MET systems, revealing infrastructural and technological gaps. Overall, these studies underscore the potential of digital technologies to enhance practical

skills and competencies among African seafarers, while pointing to persistent challenges in technological adoption and policy support.

These studies collectively highlight the ongoing efforts and challenges in integrating digital technologies into MET across various African nations. They underscore the importance of adapting training programs to incorporate modern tools and methodologies to enhance the competencies of seafarers and align with international standards.

Despite the growing global interest in integrating digital technologies, simulation, and virtual reality in maritime education and training (MET), there is a limited body of research focused specifically on African countries, including Tanzania. Most empirical studies are concentrated in developed regions such as Australia, Croatia, China, and Malaysia, while African contexts remain underexplored (Mkpandiook & Ukpai, 2017; Nhleko, 2025; Mayagilo, 1997). This gap highlights the need for context-specific investigations into how digital tools and innovative training methods are being adopted, their effectiveness, and their contribution to developing globally competitive maritime professionals in Africa and Tanzania.

METHODOLOGY

A descriptive mixed-methods design was employed to provide a comprehensive understanding of the integration of digital technologies in maritime education and training (MET) in Tanzania. This approach allows for the collection of both quantitative and qualitative data, facilitating a robust analysis of current practices and perceptions (Creswell & Creswell, 2018; Johnson & Onwuegbuzie, 2004).

The study was conducted in Dar es Salaam, focusing on key maritime institutions: Dar es Salaam Maritime Institute (DMI), Tanzania Ports Authority (TPA), Tanzania Shipping Agency Corporation (TASAC), and TEMESA. These institutions were selected due to their central role in MET and their involvement in maritime operations and regulation (Mayagilo, 1997; Mkpandiook & Ukpai, 2017). A total of 113 respondents were selected using purposive sampling to ensure participants had relevant knowledge and experience in MET and digital technology implementation (Palinkas et al., 2015; Etikan, Musa, & Alkassim, 2016).

Data were collected using structured questionnaires, semi-structured interviews, and documentary review. Questionnaires provided quantitative data on the prevalence and effectiveness of digital tools in MET, while interviews offered qualitative insights into participants' experiences and perceptions. Documentary reviews examined institutional policies and curricula relevant to digital technology integration (Flick, 2018; Nhleko, 2025).

Quantitative data were analysed using descriptive statistics and Chi² test. Qualitative data were analysed using thematic analysis to identify patterns and recurring themes related to digital integration in MET (Braun & Clarke, 2006; Guest, MacQueen, & Namey, 2012).

FINDINGS

Influence on Practical Training

The data in the table indicate that respondents generally agreed that digital technologies have had a positive impact on maritime practical training. The mean scores, which range from 3.80 to 4.07, suggest a high level of agreement across all items. The highest mean score (4.07) corresponds to the statement that digital technologies have accurately replicated real-world maritime scenarios, showing that simulation-based training is viewed as an effective substitute for real-life maritime operations. Similarly, high mean scores for items such as safe practical learning environments (4.03) and reduction of training expenses (3.98) reflect respondents' recognition of the efficiency and safety benefits of digital tools.

The weighted mean of 3.94 further confirms that, overall, participants perceive digital technologies as substantially enhancing practical maritime training. Moreover, all chi-square tests are statistically significant ($p < 0.01$), indicating that the observed agreement among respondents is unlikely to be due to chance. This statistically significant result reinforces those digital technologies are widely perceived as improving learning safety, reducing costs and time, and facilitating faster transfer of theoretical knowledge to practical skills.

Table 1. Influence on Practical Training

Practical Training	Descriptive Statistics				Chi-Square test		
	N	Min	Max	Mean	Chi ²	DF	P-Value
Have accurately replicated real-world maritime scenarios for effective practical learning.	104	1	5	4.07	73.69	4	< 0.01
Have enabled practical learning in a safe environment.	104	1	5	4.03	67.64	4	< 0.01
Have reduced expenses for maritime practical training.	104	1	5	3.98	82.25	4	< 0.01
Have offered personalized learning experiences tailored to individual student needs in practical training.	103	1	5	3.91	84.84	4	< 0.01
Have reduced the time required for maritime practical learning.	104	1	5	3.90	113.69	4	< 0.01
Have sped up the transfer of theoretical knowledge to practical skills.	104	1	5	3.87	47.92	4	< 0.01
Have increased student engagement during practical sessions.	101	1	5	3.80	114.59	4	< 0.01
WEIGHTED MEAN				3.94			

Contribution to Competent Professionals

The results presented in the table indicate that respondents generally perceived digital technologies as having a substantial positive impact on the enhancement of professional competencies among maritime trainees. The mean scores, which range from 3.92 to 4.15, reflect a high level of agreement, suggesting that the integration of digital tools in maritime education and training (MET) significantly supports the development of essential cognitive and practical skills. The highest mean score (M = 4.15) corresponds to the statement that digital technologies have enhanced problem-solving skills, implying that simulation-based learning and virtual training environments effectively foster analytical thinking and operational decision-making abilities that are critical in maritime contexts.

Similarly, high mean values for retention of complex maritime concepts (M = 4.12) and enhancement of critical thinking skills (M = 4.12) demonstrate that digital platforms facilitate deeper learning and engagement with complex operational scenarios. Respondents also recognised the contribution of digital tools to rapid decision-making (M = 4.00) and increased self-confidence (M = 3.98), highlighting the psychological and behavioural benefits of technologically mediated training.

The weighted mean of 4.04 signifies an overall strong consensus that digital technologies enhance maritime competencies. Furthermore, the chi-square test results ($p < 0.01$) across all items confirm that these findings are statistically significant, indicating consistent agreement among respondents. Collectively, these results underscore that the integration of digital technologies in MET enhances not only technical proficiency but also cognitive, affective, and decision-making competencies essential for producing globally competitive maritime professionals.

Table 2: Contribution to Competent Professionals

Competency Enhancement	Descriptive Statistics				Chi-Square test		
	N	Min	Max	Mean	Chi ²	DF	P-Value
Have enhanced problem-solving skills crucial for maritime professionals.	104	1	5	4.15	74.37	4	< 0.01
Have improved retention of complex maritime concepts	103	1	5	4.12	77.05	4	< 0.01
Have enhanced critical thinking skills among maritime students.	104	1	5	4.12	47.15	4	< 0.01
Have enabled the ability to quickly make decisions.	102	1	5	4.00	125.06	4	< 0.01
Have instilled self-confidence through emotional states.	103	1	5	3.98	136.76	4	< 0.01
It has provided unambiguously positive results in maritime learning.	104	1	5	3.92	105.62	4	< 0.01
WEIGHTED MEAN	4.04						

DISCUSSION

The findings of this study demonstrate that digital technologies play a pivotal role in bridging the gap between traditional maritime training and the evolving demands of the modern shipping industry. Consistent with previous research, simulation-based learning and the use of virtual reality (VR) and augmented reality (AR) technologies have been shown to enhance practical skill acquisition, situational awareness, and decision-making competencies among maritime trainees (Narayanan & Emad, 2022; Boguslawski et al., 2022). These technologies replicate real-world maritime scenarios, offering safe, cost-effective, and interactive environments for learning complex operations that were traditionally conducted on physical training ships (Edirisinghe et al., 2016; Sharma, 2021).

Moreover, the integration of simulators and digital tools aligns closely with the International Maritime Organisation (IMO) and Standards of Training, Certification, and Watchkeeping (STCW) requirements, which emphasise competence-based education and the use of technology to ensure consistent global standards (IMO, 2019d; Yildirim et al., 2022). As such, the growing adoption of digital tools in maritime education enhances the global employability of Tanzanian graduates, positioning them to meet international standards and labour market expectations (Nhleko & Yamkela, 2022; Anabia-Tiah, 2022).

However, despite these benefits, the study also identifies persistent challenges, including the high costs of advanced simulators, the need for continuous technological upgrades, and inadequate funding for maritime education and training institutions. These constraints are consistent with prior studies conducted in developing contexts, which found that limited financial resources and infrastructural gaps impede the full adoption of digital technologies in MET (Mkpandiok & Ukpai, 2017; Kiplimo & Ikuu, 2016). Furthermore, the maintenance and modernisation of simulation systems require sustained investment and technical expertise, which many African maritime institutions lack (Wiig, 2019; Boonadir, 2022).

In summary, while digital technologies significantly enhance maritime education outcomes and align training with international standards, Tanzania's MET sector requires stronger institutional investment and policy support to fully realise the benefits of digitalisation. Addressing the financial and infrastructural barriers would not only improve training quality but also strengthen the global competitiveness of Tanzanian maritime professionals.

CONCLUSION

The study concludes that digital technology is indispensable in modern maritime education and training, serving as a transformative tool for enhancing both the quality and effectiveness of practical learning. The integration of virtual reality (VR), augmented reality (AR),

and simulation-based platforms has proven to significantly improve learners' technical competencies, decision-making abilities, and problem-solving skills, which are essential for developing globally recognised maritime professionals. The findings affirm that digital technologies bridge the gap between traditional training approaches and the dynamic requirements of the international maritime industry, aligning with the IMO's STCW standards and global best practices.

However, to fully realise these benefits, Tanzania must expand investments in digital training infrastructure, particularly in VR/AR simulators, e-learning systems, and ICT facilities, to ensure equitable access and continuous technological upgrades across maritime training institutions. Strengthening institutional capacity, improving funding mechanisms, and fostering partnerships with global maritime organisations will be crucial steps toward closing the maritime digital skill gap. Ultimately, sustained commitment to technological advancement will not only elevate the standards of marine education in Tanzania but also enhance the international employability and competitiveness of its maritime workforce.

RECOMMENDATIONS

Based on the study findings, several actionable recommendations are proposed to strengthen maritime education and training (MET) in Tanzania through digital transformation:

- **Increase Government Funding for Simulator Acquisition:** The government should provide more financial support to acquire and maintain advanced maritime simulators, bridging the gap between theory and practice and ensuring compliance with IMO and STCW standards.
- **Strengthen Partnerships with IMO and International MET Institutions:** Collaborating with organisations like the IMO, WMU, and leading MET institutions abroad can enhance knowledge sharing, instructor training, and access to modern digital tools, while also increasing the global recognition of Tanzanian maritime qualifications.
- **Continuous Digital Upskilling of Instructors:** Ongoing digital training equips maritime instructors with the necessary skills to effectively use simulations, e-learning, and other technologies, ensuring high-quality teaching and assessment.
- **Introducing digital assessment and simulation-based evaluations** can enhance the objectivity, efficiency, and transparency of maritime certification in Tanzania, aligning local standards with international best practices and improving the global recognition of Tanzanian-trained seafarers.

LIMITATIONS OF THE STUDY

Although this study provides valuable insights into the role of digital technology in maritime education and training (MET) in Tanzania, certain limitations should be acknowledged.

- **Geographical Scope:** The study was limited to institutions in Dar es Salaam, including DMI, TPA, TASAC, and TEMESA. This narrow scope may not fully represent the situation in other maritime institutions across Tanzania or in the broader East African region.
- **Sample Size and Sampling Method:** The study relied on purposive sampling of 113 respondents. While this ensured participants had relevant knowledge, the relatively small and non-random sample limits the generalizability of findings to all maritime professionals and institutions in Tanzania.

Recognising these limitations provides context for interpreting the findings and offers a basis for further research to broaden and deepen the understanding of digital technology adoption in maritime education.

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