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**THE USE OF EXTENDED REALITY IN
MARITIME EDUCATION AND TRAINING:
A CASE STUDY OF INDIA**

TIRTH SANJEEV VAKIL

A dissertation submitted to the World Maritime University in partial fulfilment
of the requirements for the award of the degree of Master of Science in Maritime
Affairs

2023

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

Signature: 

Date : **20th September 2023**

Supervised by: **Dr. Johan Bolmsten**
Supervisor's affiliation: Assistant Professor of Maritime Education and Training (MET) and Information Manager at the World Maritime University

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Abstract

Degree: **Master of Science**

Title of Dissertation: **The use of Extended Reality in Maritime Education and Training: A case study of India.**

Seafarers' training plays an integral role in ensuring safe operations on the ships. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (STCW), has been amended several times to encapsulate the changes and developments within the maritime industry. One of the most notable transformations in this ecosystem is the impact of digitalisation to ensure safer seas. Due to this global transformation, the Indian Maritime Education and Training (MET) system is also undergoing a digital transformation. This study examines the use and adoption of Extended Reality (XR) within the Indian MET framework. XR encompasses promising emerging and immersive technologies and it is integral to understand the role these technologies would play in catalysing the digital transition of the Indian MET.

This study targets the trainees and trainers from different Maritime Education and Training Institutions (METIs), and the sailing seafarers from different shipping companies for understanding and analysing the different perspectives on the use of XR. The study is supplemented by drawing meaningful conclusions after reviewing relevant literature, and through surveys and semi-structured interviews. The conclusions discuss the scope of adoption, usage, benefits, and challenges of XR in the MET.

Keywords: Extended Reality, Maritime Education and Training, STCW Convention, Digitalisation

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Table 1:List of trainers from METIs

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List of Abbreviations

AR	-	Augmented Reality
BIMCO	-	Baltic and International Maritime Council
DGS	-	Directorate General of Shipping
ECDIS	-	Electronic Chart Display Information System
GDPR	-	General Data Protection Regulation
ICS	-	International Chamber of Shipping
IMO	-	International Maritime Organization
LMS	-	Learning Management System
MET	-	Maritime Education and Training
METI	-	Maritime Education and Training Institute
MR	-	Mixed Reality
STCW	-	Standards of Training, Certification, and Watchkeeping for Seafarers
UNCTAD	-	United Nations Conference on Trade and Development
VR	-	Virtual Reality
WMU	-	World Maritime University
XR	-	Extended Reality

Chapter 1: Introduction

1.1: Background

According to United Nations Conference on Trade and Development [UNCTAD] (2021), the shipping industry is responsible for carrying over 80% of the volume of goods in the international trade. The maritime industry facilitates international trade and economic growth by connecting markets. The main factors driving this industry are cost, reliability, and safety (Benamara et al., 2019). The shipping industry is complex, dynamic, and acts as a crucial factor in the global economy by meeting the needs of the world-wide trade. There have been constant technological advancements and revolutionary changes globally in every eon.

Ichimura et al. (2022) suggest that the global shipping sector is rapidly evolving as a result of the technological advancements and is moving toward the era of digitalisation. The crew sailing on board should be skilled to perform the tasks efficiently, effectively and safely as the shipping industry is a multi-billion dollar industry that faces various challenges including environmental and safety concerns (International Chamber of Shipping [ICS], 2020). Thus, the seafarers need to undergo appropriate training to manage the complex operations onboard a vessel. Consequently, there should be a shift in the Maritime Education and Training (MET) framework where the current trainers are equipped to effectively train the trainees and sailing seafarers for the existing and the future of shipping. Hence, MET plays an integral role in a vessel's safety, and the seafarers currently working onboard the

vessels need to be imparted with proper training to efficiently manage the complexity of operations and maintain the safety of life at sea.

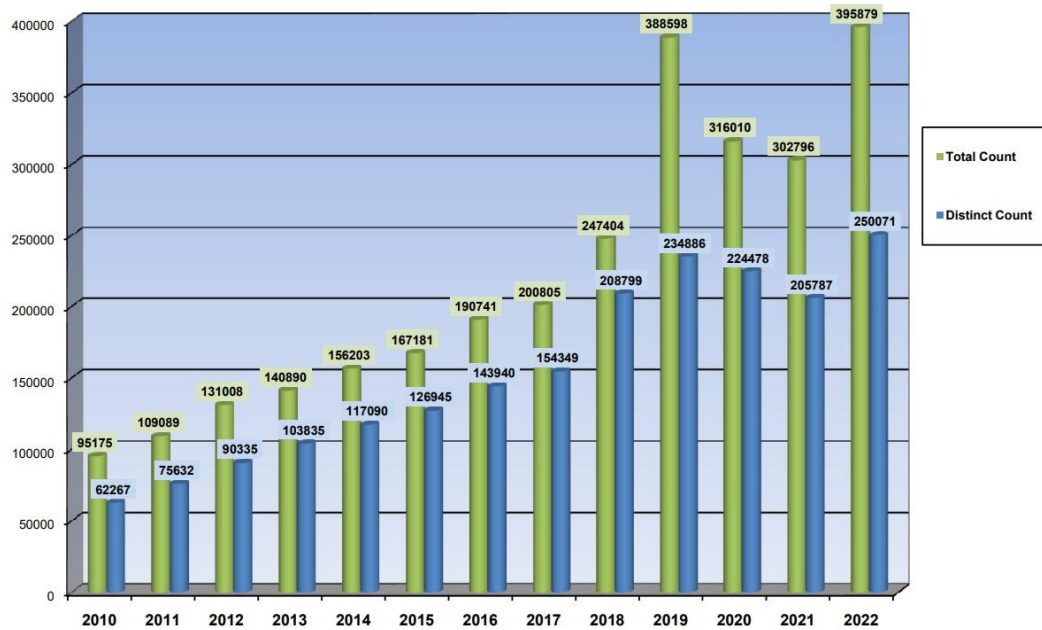
Technology, over the years, has disrupted all the industries, including the education industry. One of the most observed advantages of technology is that students explore and learn which is an innovative form of learning (Youngblut,1998). Additionally, global interruptions such as the COVID-19 pandemic have resulted in the widespread use of remote training and the incorporation of digital resources, that have the potential to disrupt MET (Renganayagalu et al., 2022). A training center's inability to respond, embrace and adapt to the quick changes, essential for the seafarers, is considered to be a big hurdle in adopting technologies.

The primary stakeholders, including flag states, classification societies, and shipping companies have begun to promote digitalisation, and have aligned their systems and resources toward it. Subsequently, a shift in the work environment would necessitate a modification of the MET systems in order to develop on the hard and soft skill sets (Mickienė & Valionienė, 2021). To meet the progressing demands of the maritime operations, Maritime Education and Training Institutions (METIs), simulator vendors, and shipping companies must offer and utilise the most effective MET programs and technologies, to embrace the digital transformation. Hence, to ensure that seafarers on board are competent in executing their responsibilities effectively, quality training requirements should be set for them by utilising the accessible resources and innovative techniques. (Kim et al., 2023).

India is the world's fourth largest supplier of seafarers, and the quality of METIs play an important role in the assurance of the seafarer's competence, resulting in the continuous supply of seafarers (Bahtić, 2021). The Directorate General of Shipping (DGS), is the Indian maritime administration responsible for recognising the sustainable development of shipping and is responsible for ensuring that Indian seafarers meet the global maritime requirements for skilled seafarers. The STCW

amendments act as a guiding light for the DGS to develop the guidelines for the aspects of governance with respect to MET (Directorate General of Shipping [DGS], 2023a). Further, they are also cognisant of the need to upgrade and simulate the use of the latest technological advancement in the field of MET. Therefore, it is essential to analyse the strategies to upgrade the skill levels within the MET in order to achieve greater productivity and effectiveness. Engagement of Seafarers in India is increasing rapidly. As per the statistics by DGS (2023b), the engagement of seafarers has increased by almost 4 folds in the last decade and it is predicted to further increase, as depicted in the figure below. Hence, India has been used as a case study for this research.

Figure 1:Engagement of seafarers during the year 2010-2022



Note: Statistics of engagement of Indian seafarers on Indian / Foreign flag merchant ships from 2010 to 2022 by DIRECTORATE GENERAL OF SHIPPING, Mumbai *DGS Circular No. 07 of 2023*.

<https://www.dgshipping.gov.in/writereaddata/ShippingNotices/202302240132533846342DGCircularNo07of2023.pdf>

India is building a robust and futuristic framework by harnessing technology leading to global maritime practices with the right mix of traditional practical training (Ravi, 2020). The maritime industry is looking for better-trained officers and India has the potential to meet the global supply of competent seafarers. Despite the traditional conservatism, there have been many changes in the shipping industry, with the key drivers of change being digitalisation (Sudhakar, 2015). The changing maritime situations emphasise formal training to a greater extent, resulting in a significant impact on the MET and METIs. These enhancements come from adapting to technological advancements and offering technical training (Thiruvassagam & Rengamani, 2015). This urged the Indian MET policy to enlarge the body of knowledge leading to encouragement and innovation. The new generation is tech-savvy, establishing their terms for a wider use of technology (Bhardwaj et al., 2022).

In India, less than 10% of the METIs have begun to explore the use of the latest virtual and digital tools, which are effective in recreating situations (HIMT, 2023). Additionally a few digital solution providers like OMS-VR, ARI, etc. are also developing various modules to allow the simulation of high-risk cases, especially the accident learning cases, leading to deeper learning and more reliable results. Many shipping companies, such as Anglo-Eastern, Wallem, Star Ocean, Star Bulk, etc. use the modules developed by the training providers to provide virtual and immersive training to their seafarers (OMS-VR, 2019). The future of MET will likely differ from the pre-COVID-19 state and hence MET will rely heavily on the efficient application of technology, which includes the use of simulators and digital tools (Kim et al., 2023).

The training on simulators in MET is crucial. Due to this requirement of the training, METI's need to be technologically prepared for a new generation of more immersive and user-friendly simulators and simulation-based experiences for education and training. Extended Reality (XR) is a prominent example of immersive technologies that are used in many different areas, such as entertainment, education, science, medicine, simulation, robotics, military applications, and more (Jagatheesaperumal et

al., 2022). This technology has the potential to expand the scope of maritime operations, education and training, maintenance and safety, thus enabling the operators to use new approaches to perform their work at sea and ashore. Therefore, it is required to adapt with the changing regulations and technological advancements to ensure safer ships and greener oceans.

1.2: Problem Statement

The global MET system is undergoing a major transformation due to the dynamic nature of the shipping ecosystem and the increasing influence on technology. The challenge is to understand the extent to which the METIs could augment and enrich conventional maritime training techniques. METIs attempt to meet the rising demand for a competent workforce by exploring new technologies and implementing novel teaching and evaluation techniques within a framework, that is both sustainable and attainable for which the new international laws are regularly enacted. Currently, the extent of the digitalisation trend in India is limited to full-scale use of generic simulators, or using a Learning Management System (LMS) which is an online platform that encompasses all the modules for the basic and competency courses in the digital format. So, it is integral to also explore the large-scale use and application of emerging digital tools like XR that have the potential to improve the effectiveness of the training of seafarers in a large and growing seafarer providing nation like India.

1.3: Aims and Objectives

This research aims to explore the current usage and the contribution XR can have on MET framework, provide recommendations to explore the opportunities for successfully adopting and implementing the technology. This research further aimed to identify the applications of XR in MET to achieve the required STCW competence for the seafarers and to increase the training standards of the seafarers. The usage of the latest technologies could have potential benefits for the smooth adoption of the

technology. Further, the operational challenges might cause a barrier to the wide scale adaptation of the latest technology, which the research aims to identify.

1.4: Research Questions

- What is the usage of XR technologies?
- Which STCW competencies and courses would XR be most applicable to?
- What are the benefits and challenges of XR in MET?

1.5: Methodology

This research was carried out using mixed methodology approach by using qualitative and quantitative analysis on trainee seafarers, sailing seafarers and the maritime training professionals having experience with the XR technologies which is an opportunity of this research. The research initially used data and content analysis to gain an understanding of the trend of XR. The quantitative methodological approach, supported by a survey, was used to address the research questions using statistics. Supplementing the quantitative approach, the qualitative approach was used to analyse the data and provide an opinion through discussions and interviews, allowing the researcher to gain a deeper understanding of the insights in elements of the XR's technologies.

1.6: Ethical Issues

Before commencing the data collection, the researcher considered the protocols stated in the World Maritime University (WMU) Research Ethics Committee. The request to conduct research involving human interventions was submitted, along with an assurance that the data gathered would be kept confidential, protected and erased after the study was finished. An E-mail invitation and the formal letter of the actual survey

instrument were provided to every participant, and the researcher also informed the participants of the data collection process. Additionally, prior to recording the interviews, the researcher ensured to get the participants' permission and approval.

1.7: Outcome of the Research

XR has the ability to cause a huge impact on the future of MET to effectively meet the different competency levels of seafarers and benefit the trainees/ apprentice officers by offering training through various modules, scenarios and processes. Further, XR could cause amendments & revisions in the regulations of the Standards of Training, Certification, and Watchkeeping (STCW). Another outcome of this research was to highlight the merits and demerits for the successful wide scale adoption and large-scale utilisation of these latest and emerging XR technologies in MET.

1.8: Limitations

The strategy of this study required the targeted respondents to provide the necessary information during the survey and interviews to understand the scope of the XR which is only limited to India. However, it is possible to broaden the research scope by incorporating more METIs in India to understand the complete trend of XR and even research on other digital technologies. Additionally, the scope of the research could be expanded by obtaining more comprehensive perspectives through the inclusion of the MET system of other countries, especially the major seafarer-supplying nations like the Philippines, Indonesia, and China.

Chapter 2: Literature Review

The purpose of the Literature Review is to contextualise the functioning of the METIs in the shipping industry and explore the potential of XR. The framework of the shipping industry, the basic understanding of the use and types of simulators & XR were expounded in this chapter. Further the operations of XR in education and training, specifically in MET were also explored in this chapter.

2.1: Framework of MET

STCW 1978, as amended, is the International Maritime Organization (IMO) instrument that governs and sets the minimum standards for training and certification for seafarers. Several amendments have been made in STCW, including minor and major ones (IMO, 2019). STCW Code and Manila amendments were the major amendments made in 1995 and 2010, respectively (Ahmad, 2017). A recommendation was made in 2010 that the STCW convention and code should be revised comprehensively every ten years to ensure they remain aligned with the existing and emerging technologies (Baltic and International Maritime Council [BIMCO], 2022).

The STCW code includes Part-A, which covers the mandatory provisions in which the parties must meet the minimum standards to give complete effect to the STCW convention, and Part-B, which is recommended guidance to assist the parties of the

STCW convention. The 2010 Manila amendments covered many aspects, which included new requirements relating to the training in Electronic Chart Display and Information Systems (ECDIS), the introduction of modern training methodology using distance learning and e-learning, etc. (IMO, 2019). The STCW is divided into eight chapters and three levels of competencies in terms of responsibilities, and seven functions. Poulis et al. (2020) predicted that digitalisation will transform the shipping industry in the near future. Kim et al. (2020) also noted that the STCW convention requires seafarers and stakeholder's cooperation to develop the skills needed to face real-world challenges and improve shipboard decision-making. Additionally, STCW code establishes the guidelines for maritime training programmes (Tusher et al., 2021).

2.2: Overview and Current Trend of MET

2.2.1: Outline of MET

The STCW convention has been regularly updated to reflect the global developments and advancements, but sea accidents persist for the same reasons and errors. Human error is still the leading cause of maritime disasters (Kassar, 2016). Current MET systems must provide skilled and dynamic training to students to help them avoid the same mistakes which lead to accidents and incidents (Alop, 2019; Kassar, 2016). De Água et al. (2020) emphasise the need for a dynamic maritime educational system to create future leaders. Thus, it is crucial to examine ways to improve the quality of training so that the future seafarers and maritime professionals may make informed decisions to maintain safer seas. To enhance the quality of training, it is important to establish an efficient MET system. Demirel & Mehta (2009) suggest that to establish an efficient and dynamic MET, a large amount of attention needs to be given to the following areas:

- Recognising and applying international standards and regulations, such as the STCW convention.

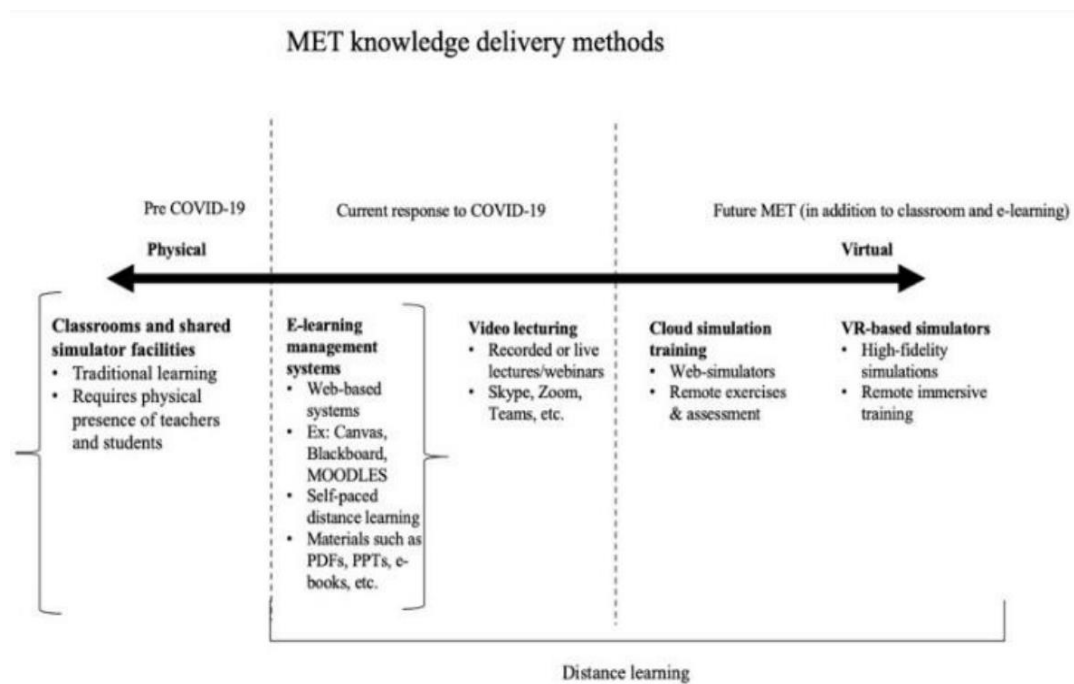
- Maintaining cooperation with the stakeholders such as the shipping companies and administration to fulfill their requirements.
- New findings and developments that impact and may cause a potential improvement in the field of MET.
- Updating the curriculum to attain continuous education and meet new requirements.
- Adopting and utilising new training technologies in MET.

2.2.2: COVID-19 and Beyond

The incorporation of technology as a classroom strategy surged in prevalence during the COVID-19 pandemic, accelerating the paradigm shift of learning. The pandemic posed an unprecedented challenge for the shipping industry to ensure the continuity of effective MET practices, leading to more reliance on online training and e-learning, which triggered the establishment of using new digital tools for training (Renganayagalu et al., 2022; Kim et al., 2021).

As depicted in the above figure, there is a change in the MET delivery methods in response to COVID-19 pandemic, and the future of MET will be different from the current delivery method. The training in the post COVID-19 era will be accomplished by synergising the traditional classrooms with the utilisation of digital tools.

Figure 2: Spectrum of MET pre and post COVID-19



Note: From “Maritime Education and Training in the COVID-19 Era and Beyond” by Renganayagalu, S. K., Mallam, S. C., & Hernes, M. (2022). *TransNav: International Journal on Marine Navigation and Safety of Sea Transportation*, 16(1). <https://bibliotekanauki.pl/articles/2086301.pdf>

To ensure uninterrupted education in the future or in the event of another pandemic, it is essential that practical solutions and learning are applied to the maritime educational ecosystem (Mallam et al., 2019a; Ochavillo, 2020). However, it remains to be perceived how the teachers, previously habituated to the physical classroom and face-to-face interaction, will adapt to the online e-learning environment and new teaching methods (Renganayagalu et al., 2022).

2.2.3: Digitalisation of MET

The maritime industry is highly interconnected and globalised, and the dynamic changes have to be accounted for, especially the MET, to continue benefiting the

students, teachers, and the marine industry as a whole from the use of technology in the present and the future (Ochavillo, 2020). Therefore, it is imperative to address the applications and challenges of digitalisation. Sandaruwan (2010) opines that the quality of training could be increased by digitalisation, such as the use of simulators, which would allow better productive & collaborative learning and training environments. In an ideal future, humans and computers will work together to maximise everyone's intellectual, social, and emotional potential (Wang et al., 2020; Bhandari, 2017).

Over the years, teachers have developed methods by drawing on several instructional aids to increase student engagement in the classroom (Dewan et al., 2023; Ziker et al., 2021). Almost all METIs strive to provide the educational process with aided tools such as simulations, video conferencing, online learning tools and e-libraries (Marichev, n.d.). This would accommodate the maritime industry's constant technological innovation and its implementation. Currently, MET is undergoing digitalisation and automation, but there is a lack of clarity on the future in terms of accountability and competence. This can affect the future of training in MET. However, it is essential to understand the opportunities for MET due to technological advancements. Erdogan & Demirel (2017) suggest the following benefits of incorporating new technologies within the MET context:

- Enhancing the students abilities to perform the shipboard duties.
- Improving management skills of the cadets to analyse the risk and ensuring proper management at sea.
- Preparing training programs to meet the academic and vocational requirements.
- Building up IT skills.
- Ensuring cooperation with the shipping companies to enhance the quality of training onboard.
- Having fully equipped laboratories to simplify the delivery of the subject.
- Ensuring life-long learning which is an essential part of quality education.

- Reflecting real-life situations and apply to have more understanding of the utilisation of simulators.

2.3: Simulators

Simulators are used as a complementary means of training in current MET practices to the extent that, in certain circumstances, it is also used as a substitute for onboard training to a certain degree (IMO, 2019). The current trend of training on simulators has been by the approach of increasing the fidelity and focusing on scaling of the simulators. The simulators range from desktop-based simulators to the full mission simulators, which are more realistic. Simulators can be classified into Class A, B, C, and S which are full mission, multi-task, limited-task and special tasks, respectively (Kim et al., 2021). The advancement of technology has gradually increased the immersiveness and effectiveness of simulators, providing an advantage to seafarers by facilitating various skills, playing different scenarios, and understanding behaviours in a risk-free environment. This allows access to feedback, discussions and gives room for making mistakes that cannot be afforded in the real world (Renganayagalu et al., 2019).

Mallam et al. (2019b) express, that computer-generated simulations have been used as training applications for decades; digital technology and simulations must be explored in tertiary and vocational education. Mallam et al. (2019a) believe that emerging technologies and simulation tools like XR are used as a supplement to traditional teaching methods. Such training will improve a seafarer's ability to deal with daily operations on board. Thus, METIs should adopt new technologies and use digital and immersive tools like XR.

2.4: Extended Reality

Extended reality also called XR, has been adopted as an umbrella term, which includes Virtual Reality (VR) / Augmented Reality (AR) / Mixed Reality (MR) technologies, and the metaverse (Guo et al., 2021; Kim et al., 2023). Chuah (2019) suggests that XR would revamp the way the users view the physical and virtual environments that is from observation to immersion methods. The detailed discussion on VR, AR, MR and Metaverse is as follows:

2.4.1: Virtual Reality (VR)

VR is an advanced technology simulating interactive experiences using computer-generated simulations or environments. It is a clone that gives the feel of reality, though not physical. It uses special headsets or devices that let people interact with virtual worlds. The prominent VR headsets are Oculus, Rift, HTC Vive, and Samsung HMDs (Mallam et al., 2019a).

Figure 3: Virtual Reality



Note. From *VR in Maritime Institutes*, by HIMT, 2023 (<https://himtcollege.com/vr-in-maritime-institutes/>). Copyright 2023 by HIMT College

2.4.2: Augmented Reality (AR)

AR is a technology that involves the overlay of digital information or elements onto the real world. It refers to the practice of superimposing computer-generated data onto a real-world view, either directly (via see-through displays) or indirectly (via a camera). The prominent AR Headsets are META Quest Pro and Google Lens (Chuah, 2019; Mallam et al., 2019a)

Figure 4:Augmented Reality



Note. From *AR in Maritime Institutes*, by HIMT, 2023 (<https://himtcollege.com/ar-in-maritime-institutes/>). Copyright 2023 by HIMT College

2.4.3: Mixed Reality (MR)

MR is an overlay of a real-world environment with digital, computer-generated objects and allowing the users to interact with them. MR merges real and virtual worlds where the digital and physical worlds exist and interact in real-time. For example: Microsoft HoloLens (Mallam et al., 2019a).

Apple in June 2023, released their highly anticipated MR headset called Apple Vision Pro. This headset is anticipated to be the landmark in synergising the real and digital world. “The primary user interface relies on eye tracking, hand, gestures, cameras, and sensors, eliminating the need for physical controllers such as keyboards or touch screens. The refined capabilities of this technology can be utilised for diverse purposes” (Apple Vision Pro, 2023; Waisberg et al., 2023).

Figure 5: Mixed Reality



Note: From *Maritime's Amazing World of Mixed Reality* by Fostech AS. Mulligan Tom. 2019, MARINELINK (<https://www.marinelink.com/news/maritimes-amazing-world-mixed-reality-462876>). Copyright 2023 by Maritime Activity Reports, Inc.

2.4.4: Metaverse

The metaverse is believed to be the next evolution of the internet, a single, shared, immersive, persistent virtual space where humans can experience existence in ways they cannot experience in real life. It consists of Experience, Discovery, Creator economy, Human interface, Decentralisation, Spatial computing, and infrastructure (Jagatheesaperumal et al., 2022; Laeeq, 2022)

Figure 6: Metaverse



Note: From, Will we see Metaverse M & A accelerate in 2024? By Coruzant technologies. Tober Dyan. 2023. Coruzant technologies (<https://coruzant.com/virtual-reality/will-we-see-metaverse-ma-accelerate-in-2024/>) Copyright 2023 by Coruzant.

The participants in the images are diving into the future and experiencing the use of diverse range of modules to enhance the learning and immersive experience.

2.4.5: Background & Benefits of XR

Recently, XR technologies have gained popularity across industries, resulting in more powerful, affordable, and advanced software and devices compared to previous generations (Çöltekin et al., 2020). Previous uses of XR were limited to labs or specific sectors like automotive, construction, aviation, and emergency preparedness. This is now spreading to other businesses, including education (Alnagrat et al., 2021).

XR allows individuals create and learn spatial experiences in their environments. Spatial computing has advanced, enabling citizens to map their environment in real-time using smartphones and giving high-fidelity 3D information (Çöltekin et al., 2020; Guo et al., 2021). Further, XR delivers strong and new visualisation and interaction experiences. The designs alter the perception of space (Çöltekin et al., 2020). XR refers to the cumulative spatial experiences that create well-designed, compelling, and meaningful information experiences (Guo et al., 2021).

Gaudiosi (2015) & Martín-Gutiérrez et al. (2017) discuss that huge technology firms and multinational companies such as Google, Facebook (Meta), Microsoft and Apple have invested millions of dollars considering the potential benefits of these tools in the near future. They are confident that AR/VR applications can provide consumers with an enchanting experience. Further, Alnagrat et al. (2021) believe that XR has many operational capabilities, and they view that the demand for XR has risen exponentially, especially in high-risk occupations and training.

2.5: Extended Reality in Education

2.5.1: Scope

XR technologies have the capability to improve the quality and delivery of education in many areas by providing high-volume cross-site interactive learning at a lesser cost. XR technologies are beneficial as they offer at least non-inferior, if not superior, results compared to conventional learning methods (Guo et al., 2021). As the students perform tangible activities, these systems frequently offer digital support through scaffolding, hints, and supplemental content.

Interactivity and immersiveness amongst participants are likely the outcomes of sustainable learning, and XR technologies is powerful at facilitating collaboration and shared experiences (Langset et al., 2018). With the help of XR technologies, learning

can be made possible in scenarios and settings where it may not have been before. This increases the learner's experience to gain a concrete understanding of various tasks and activities. It could further be considered as a method for comparing and tailoring the educational experience for each individual student (Zweifach & Triola, 2019). As a result of the immersive nature of these technologies, the learning process may be more student-centric and situated learning may be facilitated, providing students easier access to information that was previously inaccessible to them (Pottle, 2019; Alnagrat et al., 2022). This technology can be implemented in education through two ways: technology-driven and learner-driven (Kapenieks et al., 2012).

XR incorporates computational applications into wearables, giving viewers a taste of both the physical and the virtual world in terms of their human-computer interaction. These aspects would accomplish the user's goal by developing sustainable design and the system's process after the hybridisation of physical and digital spaces (Issa & Isaias, 2022; Zwoliński et al., 2022). For a smooth operation, the SOR framework should be maintained which consists of three components that are "Stimuli: any modality that initiates a cognitive or affective response within the user, Organism: the internal evaluation undertaken by the user and Response: outcomes from the use of immersive technology" (Logeswaran et al., 2021). XR allows learners to control their learning strategies, thereby enhancing the connection between the students and the teachers (Boyles, 2017).

2.5.2: Effectiveness

XR offers dynamic, accessible, and adequate education models to give students a realistic, risk-free learning environment. Further, XR encompasses simulated or synthetic environments combining the real and digital world. The virtual world's modelling and recreation capabilities could help educators make learning more engaging, creative, and useful. VR enables interaction with high-risk or inaccessible

activities, and AR allows interaction with non-physical objects (Logeswaran et al., 2021).

Several studies have explored the effectiveness of technology application in education through blended and physical modes in various streams such as biological experiments, education related to art, language, music, etc. Many institutions like Colorado State University and Florida International University have begun exploring the XR technologies to enhance the quality of training and research (HP, 2023). Even Indian institutions are moving and transforming their system to utilise these technologies such as Manipal Academy of Higher Education, Gandhi Institute of Technology and Management, Mahindra and Sharda University (Money control, n.d.). Smart education product design, the incorporation of game-based learning, the creation of a smart learning environment, design teaching and the instruction of students with special needs are all examples of applications of XR educational scenarios (Sheu & Chen, 2014). Alnagrat et al. (2021) believe XR provides educational solutions and offer more critical skills, sensory feedback and real-time performance evaluation. For instance, they hold abilities to inspect virtual store tours, rehabilitate brain injuries and conduct surgeries (Flint et al., 2022).

According to Bhardwaj et al. (2022), XR technologies makes learning more desirable in sectors like safety training, ship survey training, firefighting/rescue operation. VR learning provides significant success to adopt new generation training and learning methods. XR may assist to solve the issue of authentic training, to help the marine sector move into the contemporary era. They further add that XR technologies are used nearly in every industry having the ability to enhance the security, efficiency, and reduce the cost. However, they argue that VR fails to give more authentic learning experience and has certain restrictions, such as students may experience motion sickness.

2.6: Extended Reality in MET

2.6.1: Outline of Extended Reality in MET

XR has been limitedly adopted for education across different industries and its potential in MET is untapped. These immersive technologies have drawn fresh attention in a traditional classroom setting (Dewan et al., 2023). The nomination of the appropriate engagement and motivation methods can inspire and enhance the learning procedure for students, who have historically played a central role in reducing the achievement of learning (Hsieh, 2021; Mallam et al., 2019a). Mallam et al. (2019a) suggest that despite the technological progress, a key concern is that the trainers within METIs would have to scaffold their skills to adapt their teaching methodologies to include XR technologies, especially over time as more complex technologies are introduced to MET.

Renganayagalu et al. (2022) argue that online and hybrid methods of education are becoming increasingly popular, especially within the spectrum of XR technologies that stretch from the real world to fully immersive computer-generated simulation. The first step toward continuous collaboration and effective learning would be to encourage educators to advocate for the incorporation of technology-assisted learning into MET (Marichev, n.d.). Hence, XR technologies will have an impact on the formation of future maritime professionals' enhancing their competence because they provide the closest possible training conditions for sailors (Voloshynov et al., 2020).

2.6.2: Virtual Reality in MET

VR has the potential to transform MET as, it creates realistic simulated settings in which students can practice a variety of nautical, and engineering skills (Guo et al.,

2021; Mallam et al., 2019a). VR-based simulations are highly engaging because they render the virtual environment with extreme detailing and completely immerse the users in these virtual environments, thereby promoting a high level of the psychological presence. VR has the potential to increase the safety of future MET, where relevant stakeholders may take advantage of its ability to create situated learning experiences in a safe environment. VR has the potential to make training available to a wider range of audiences including the personnel from shore to create extremely complex and realistic representations of scenarios that are hard to create like performing actions within an engine room multiple times, or perform an enclosed space entry in a controlled and a safe environment (Makransky & Klingenberg, 2022; Mallam et al., 2019a).

Kinateder et al. (2014) suggest that a firefighting module could be developed consisting of a VR firefighting simulator. Similarly, it can be customised for a merchant navy's training program which includes the development of a firehose controller, leading to an effective training and evaluation. Mallam et al. (2019b) suggest that the omnipresence and the strong computing power of the VR technologies and headsets would create new opportunities for personalised and immersive simulation experiences that can be used anywhere. Additionally, the authors opine that by initiating discussions for the need to investigate and implement these technologies, the users could be one step closer to having sustainable and appropriate experiences for a lifelong learning.

2.6.3: Augmented Reality in MET

Dewan et al. (2023) discuss that AR can change the training methods as this technology has the potential to identify vital objects in a single view and offer the operation and maintenance guide. AR can facilitate the integration of instructive text, films, and 3D virtual objects onto essential components, enabling animation. Balcita & Palaoag (2020) describe that developing an AR model would enable METIs to

introduce smart technologies combined with innovative thinking, which will alleviate the hands-on training techniques while teaching students. This model could be used to supplement the learning experience of students on several maritime programs in the future. This design can lead to an innovation in MET by complementing the learning strategies during a topic delivery by enhancing the student's experiences. For instance, an AR prototype model of a ship could be developed wherein the model could be shifted from a 2D to a 3D plane, zoomed in/out, turned, etc. and this could assess the learning experience as required. Further, this AR model could be uploaded to the internet, then this could be easily stored and downloaded to the smartphones for personal learning enhancement and experience.

2.6.4: Mixed Reality and Metaverse in MET

The MR technology incorporates game design. Further, the game design elements have the potential to boost the output and engagement by motivating the participants and training them on emergency scenarios. Kim et al. (2023) suggest that the online learning methods which includes the use of XR within the metaverse come under the category of high learner participation which creates education opportunities. Further, by employing XR within a metaverse setting, learners can use educational information while engaging in real-time communication with colleagues accessing the space from different locations.

2.6.5: Importance of Extended Reality in MET

The objectives of implementing and utilising information technology in MET necessitates the level of competence of marine specialists in the marine industry. This leads to the execution of the virtual environment of METIs by the means of head-mounted headsets, through which learning is enhanced by observing through the experience of others and participating in tasks multiple times until the accurate responses are achieved (Marichev, n.d.). It further, promotes individual training and

enables a group to be trained simultaneously which enhances the safety, concentration, and awareness of the training. Jagatheesaperumal et al. (2022) opine that “development of educational content for addressing cybersecurity issues through virtual ships, maritime accident reproduction, maritime operations, and related online learning content” are few of applications of XR in the maritime industry.

The MET program, as stipulated by the STCW, mandates that learners acquire knowledge, understanding, and proficiency pertaining to the utilisation of specialised equipment such as cargo machinery and work tools. However, it is also imperative to examine the aspect of instructional design, which involves considering the distinct attributes of learning encounters facilitated through XR.

2.7: Chapter Summary

The current MET system needs to provide quality training to the students with more real-world experiences to ensure skilled labour comes into the market, which reduces the risks and errors onboard that lead to accidents and incidents. Ziarati (2010) suggests that the STCW convention could be more valuable and practical if it underwent further revisions and updates, resulting in safer trade and safer operations of the ships. The training of seafarers has transitioned from traditional classroom methods to augmenting traditional training with simulator training over the past decade. To meet the global standards and enhance the quality of training, traditional classrooms need to encompass immersive, scalable, and risk-free environments to the trainees and sailing seafarers, increasing student engagement, and enhancing their real-world preparedness technologies like XR to provide immersive environments to the users.

Currently, only a few METIs and shipping companies have commenced the exploration of XR technologies and are yet to make notable advancements in the adoption for the same. Hence, the potential of large-scale utilisation of XR, is yet to

be explored and adopted by METIs to enhance the quality of MET. Despite the growing literature on the usage of XR technologies in education, there exists an explicit considerable gap in research, specifically in the role of XR in MET. This ability could make XR a gifted tool for a wide range of elements benefitting the whole maritime community.

Therefore, this research aims to go deeper in recognising the current usage of XR technologies, using India as a case study to determine the additional insights and understand the different scenarios of the usage of XR. The previous research is limited to XR in general settings and there is not considerable degree of study on benefits and challenges of XR in MET, and the role of XR related to STCW from the stakeholders having the experience with the technologies. This research aims to contribute in filling the gap by offering a comprehensive analysis on the implications of XR within MET and to contribute to understanding the usage of these technologies, and present and potential applicability of XR in context of STCW and other courses. Further, the XR technologies can play a major role to supplement the competency development of seafarers who are ready to meet the demands of the future, and hence this research expands upon the under-explored benefits and challenges of XR in MET.

Chapter 3: Research Methodology

3.1: Introduction

This chapter provides a comprehensive examination of the research methodology to explain the alignment of the methodology with the study's objectives. This research followed a mixed methodology, combining quantitative approaches, through detailed surveys, and the qualitative approaches, through interviews.

3.2: Methodology

The purpose of the analysis in this mixed methodology was to identify the issues related to XR in MET. The method adopted meets the appropriate objectives to complete the research. The research methodology aimed to empirically validate the findings to determine the extent of the topic and to achieve the results by attributing the data of the various stakeholders. According to Hennick et al. (2020), using a mixed methodology of quantitative and qualitative analysis comprising of surveys and semi-structured interviews respectively, are instrumental in investigation of the issues, finding holistic perspective in the responses to the research questions, and meeting the stated research objectives. It further produces more sound and scientific results by utilising the qualitative stakeholder approach and quantitative outcomes (Ivankova & Wingo, 2018).

3.3: Target Sample

The trainee seafarers, sailing seafarers, and the trainers who have experience with the XR technologies were the target sample for this research. This target sample has experience with XR technologies, which is an opportunity in this research as XR training is still novel. First, a target sample of trainee seafarers who are undergoing pre-sea training from the METIs and the sailing seafarers across all levels sailing in different companies having the infrastructure of XR technologies were targeted for the survey to understand the nature of training which they are undergoing. To analyse the perspectives of the participants, it is necessary to understand the distinction between the seafarers. Further, the trainers who are training the seafarers in the METIs having the infrastructure of XR technologies were also targeted to collect data relating to their scope, usage and experience of the XR technologies. The survey helped to address the research questions pertaining to the XR technologies. The trainers training the seafarers in the METIs having these XR technologies were chosen to give the researcher a different perspective.

Additionally, the researcher carried out qualitative research through interviews. The researcher developed semi-structured interviews for data collection and targeted different trainers of the METIs to get an in-depth insight to supplement the survey. The researcher targeted 3 METIs having the infrastructure of the XR technologies which is an opportunity in this research. In addition to that another METI was targeted which was in the process of setting up the necessary infrastructure for XR training, which helped the researcher get another dimension to understanding the scope and usage of XR technologies in MET, adding immense value to the research.

3.4: Research Instruments

3.4.1: Quantitative

First, the quantitative information was gathered by the means of analysed content which was decided as the basis of the survey distributed. The survey consisted of distributing the questionnaires with most of the questions on a Likert Scale, as they are more likely to yield dependable data that lead to more valid interpretations (Nemoto & Beglar, 2014). The scale is established in such a way that it moves from a weaker endorsement, that is from a less agreement (Strongly disagree) to a stronger endorsement/ agreement (Strongly agree) of the task. Another reason for the use of the Likert Scale is its ease of understanding, constructing, and analysing, which was administered effectively in conjunction with other data-obtaining approaches to achieve more well-structured understanding of the research. Further, the questionnaire also included different formats of questions like multiple choice questions, check box tick type of questions, short and long answer questions, to achieve a better outcome of the research. The researcher prepared different questionnaires for trainees/ sailing seafarers and trainers covering overlapping topics to differentiate and analyse the perspectives of both the trainers and trainees/sailing seafarers with respect to the training needs of XR.

The collected responses enabled the researcher to meet the objective of this study and understand the holistic overview and scope of XR in MET. The questionnaires were initially created as hard copies before being converted into online forms for distribution. The online questionnaire was used because it was more favourable to receive a larger number of responses and because they are more flexible, efficient, and facilitate quicker analysis. The data from the questionnaires were converted into spreadsheets and compiled into pie charts and graphs for analysis.

3.4.2: Qualitative

A general overview of semi-structured interviews is discussed below:

- A brief discussion about the application of XR in training at their respective METI.
- Their perception of the seafarers and the administrations in ensuring the competence and changes in the competence levels of the seafarers, which would affect the training for the seafarers.
- The perception of the interviewees on the current status of XR in MET and their future scope.
- Benefits and challenges of XR technologies.

Due to geographical constraints, semi-structured interviews were conducted through Zoom and WhatsApp. The meeting was recorded with the permission of the interviewees. The interview was carried out for about 30 minutes each, resulting in meaningful interactions and valuable insights and perspectives. The nature of the questions asked and the interactions between the interviewer and the interviewee are crucial tools for obtaining a successful outcome and maximising results (Ryan et al., 2009). Next, the researcher analysed and transcribed the qualitative data from interviews. The qualitative analysis was done manually and using the NVivo software. Finally, the outcome of the analysis was synthesised with the information obtained from the interviews. The interview was then transcribed and analysed, and a thematic analysis of the qualitative data was conducted. The thematic analysis allowed the researcher to discuss the participant's perspectives in their own words. According to Lochmiller (2021), this has the potential to reduce huge data into clearly expressed thematic statements.

3.5: Ethics Statement

The researcher maintained the highest value of integrity during the research and followed the protocols of the University which included taking maximum care and diligence to ensure the confidentiality of seafarers and the METI instructors who participated in the research.

There are several remarks from the respondents and interviewees that were targeted in the analysis below, and their names have been kept anonymous to maintain standards of ethics. Shaw (2008), opines that the ethics research design is based on informed consent, confidentiality, privacy and social justice which pose distinctive demands. The researcher ensured that the respondents' participation was voluntary and assured the respondents that they were safe for expressing their opinions. The consent of every participant was taken to make them feel comfortable and to comply with the ethical guidelines.

3.6: Chapter Summary and Structure of Research Analysis

This chapter discussed the methodology used for the dissertation. The means of mixed methodology using questionnaire and the interviews were carried out in this research on the different stakeholders having the experience of using XR technologies, indicating the opportunity in the research. Further, the development of target sample and validation of the research instrument were also elaborated in this chapter. The target sample were selected through the network of researcher. Additionally, the importance of maintaining the ethics were highlighted in the section.

The questionnaires and interviews are analysed in the following chapters. In the next chapter, the interpretation of the quantitative data is conducted. The survey gave the researcher a base for addressing the research questions and represent a broad overview of understanding the importance of XR technologies in MET. The chapter 4 also

provides valuable inputs for the qualitative analysis and chapter 5 presents a detailed analysis and findings. The interviews gave a detailed insight into addressing the research questions and understanding the importance of XR technologies after considering the perspectives of the different stakeholders in the survey.

Chapter 4: Quantitative Analysis and Findings

4.1: Surveys

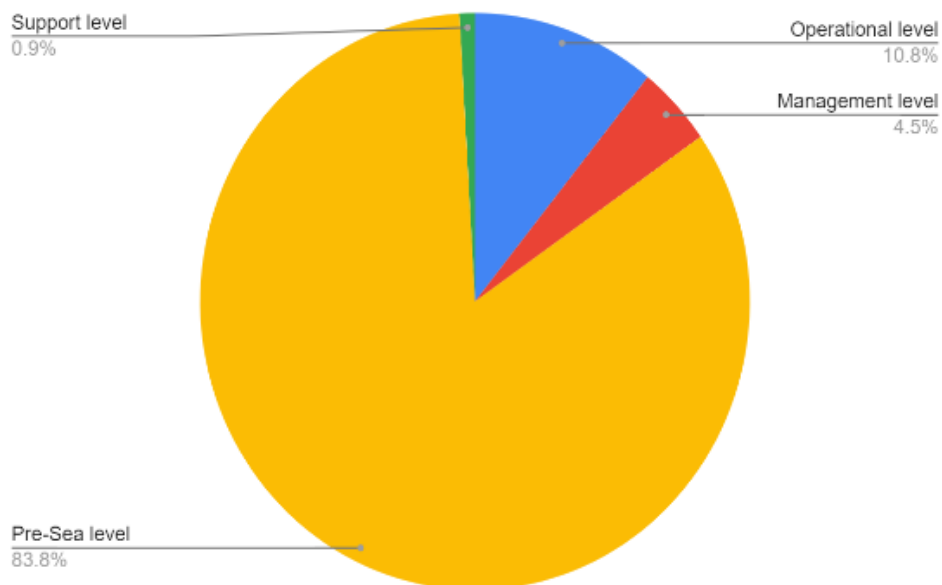
In this chapter, the analysis and findings from the survey gathered are presented. The researcher received responses from trainees, sailing seafarers and trainers from both the Nautical and Engineering departments of 3 METIs and 3 shipping companies having the experience of using XR which is an opportunity in the research. A total of 145 responses were received from the target group which were used in this research, as the respondents have the knowledge about the XR technologies. Out of the total responses received, 111 responses were from the sailing seafarers and the trainees, and 34 responses were received from the trainers. These varied responses from the trainees, sailing seafarers and trainers gave the researcher multiple perspectives to accurately analyse the data. The pie-chart consisting of 5-point Likert-scale is divided into colour coding segments ranging from strongly agree to strongly disagree. Strongly agree is blue, agree is green, neither agree nor disagree is yellow, disagree is orange and strongly disagree is red. The analysis and findings of surveys have been carried out in the below sections.

4.2: Usage of XR

4.2.1: Perspective of Trainees and Sailing Seafarers

The survey was carried out with pre-sea trainees from different METIs and sailing seafarers working onboard ships in different departments like management, operational and support levels. The figure 7 presented below gives an overview of the breakdown of the category of the respondents. Over 84% of the respondents were trainee seafarers. Out of the remaining 16% of the respondents who are sailing seafarers, 10% of the respondents worked in the operational level and 5% of the respondents worked on the management level. The remaining 1% of the respondents were the seafarers working as support-level staff. Respondents from different age groups working in different departments onboard ship were targeted.

Figure 7: Target-trainees and sailing seafarers



Most of the respondents who have worked in different ranks are more familiar with VR among the other XR technologies. As presented in the figure 8, over 92% of the

respondents, comprising of the trainee seafarers and active seafarers have used VR technologies. The survey also suggests that many respondents are not very familiar with other XR technologies like AR and MR and hence there is an untapped growth potential for these technologies.

Figure 8:XR technologies usage-trainees and sailing seafarers

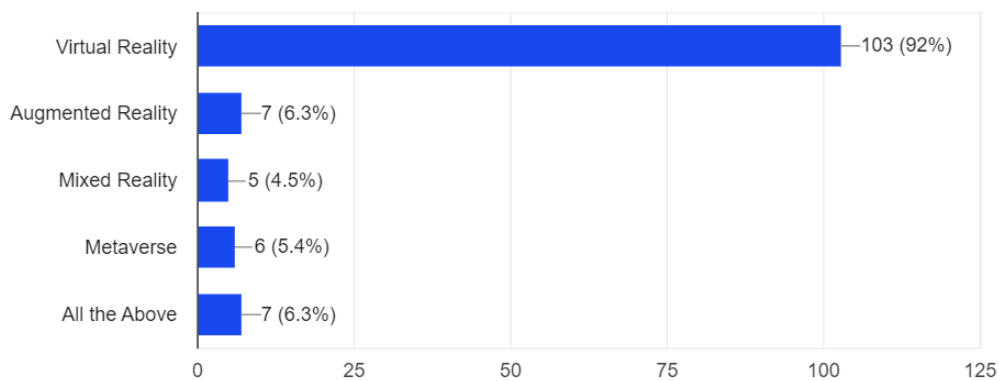
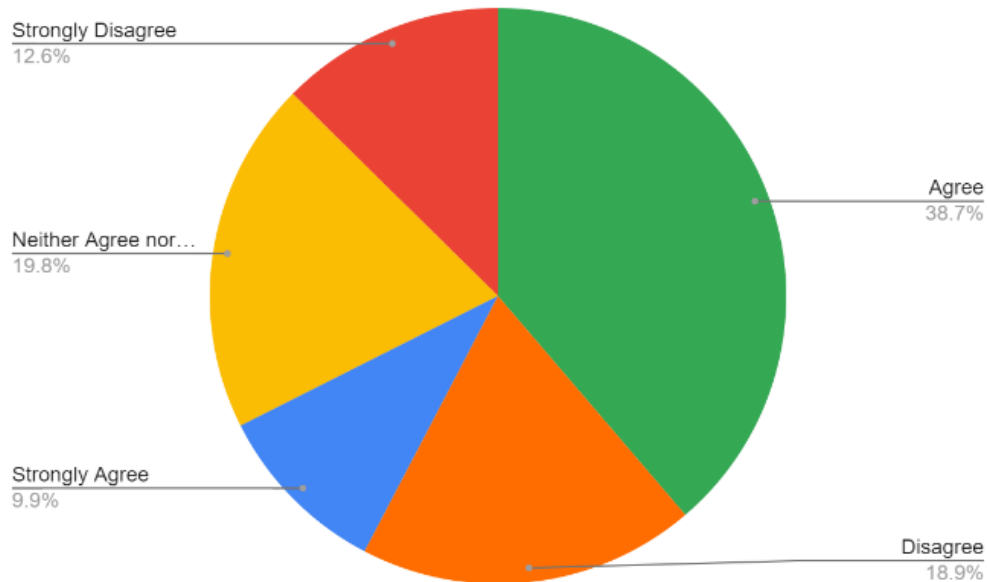


Figure 9 indicates the respondents' view about the usage of XR tools for training at METIs. Over 47% of the respondents agreed that the XR tools are frequently used at their METIs, implying that many METIs are seeing a potential in these XR tools to enhance the quality of training. Further, over 30% of the respondents opine that XR tools were not frequently used at their METIs, which implies that the stakeholders within the METIs, like the trainers might be facing challenges in embracing new technologies. This indicates that there is more potential for the frequent usage of these technologies.

Figure 9: Frequency of XR usage -trainees and sailing seafarers



4.2.2: Perspective of Trainers

The questionnaires were also shared with trainers. While both the trainers and the trainee/sailing seafarers shared similar perspectives on some questions, their difference in perspectives helped the researcher get a holistic view of the usage of the various XR tools and their potential to enhance the learning objectives.

Figure 10 illustrates the level of the trainers. Over 80% of the trainers worked at Management level, and over 11% and 9% of trainers worked at Support level and Operational level respectively. Further, the teaching experience of the trainers was also collected and analysed. Figure 11 depicts the teaching experience of trainers. Around 50% of the respondents had over 10 years of teaching experience, which was valuable for this research since they are experts in their field and have a better understanding of the needs of the trainee seafarers. Further, over 25% of the trainers have less than 5 years of teaching experience, suggesting that they are new to the MET ecosystem, and they could be moulded by the METIs to incorporate new teaching methods. Further,

it's also assumed that their perspectives would be more inclined towards the new technologies as they might have used these technologies onboard vessels or during their company training programs.

Figure 10: Target-trainers

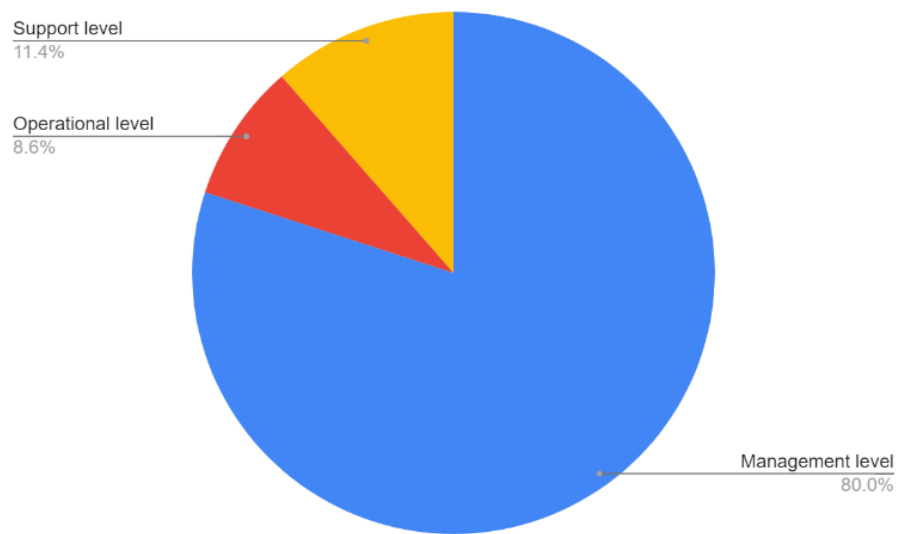


Figure 11: Teaching experience-trainers

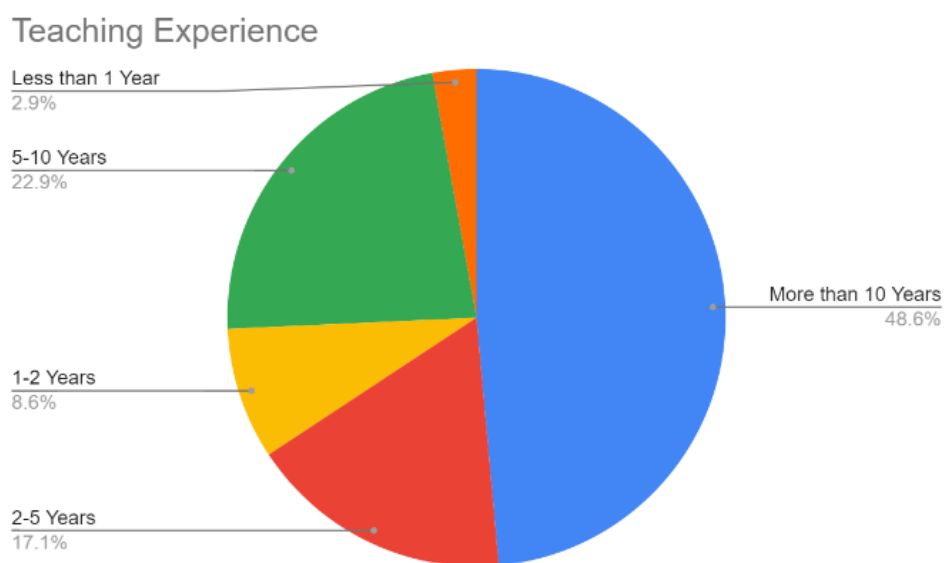
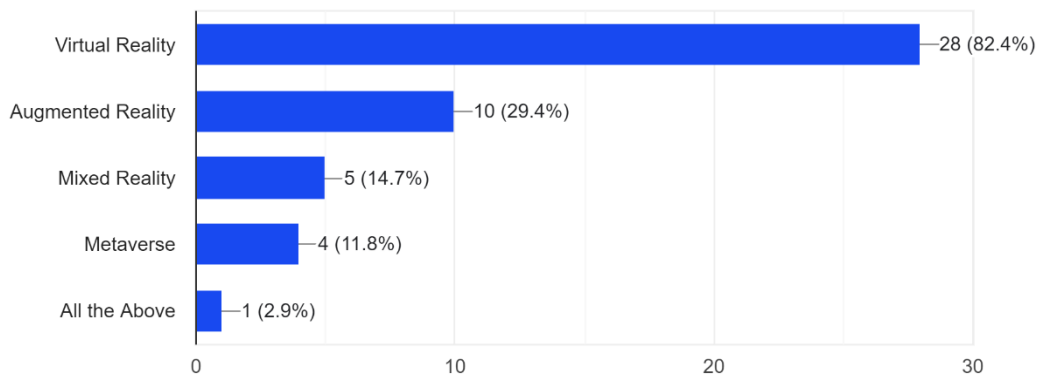


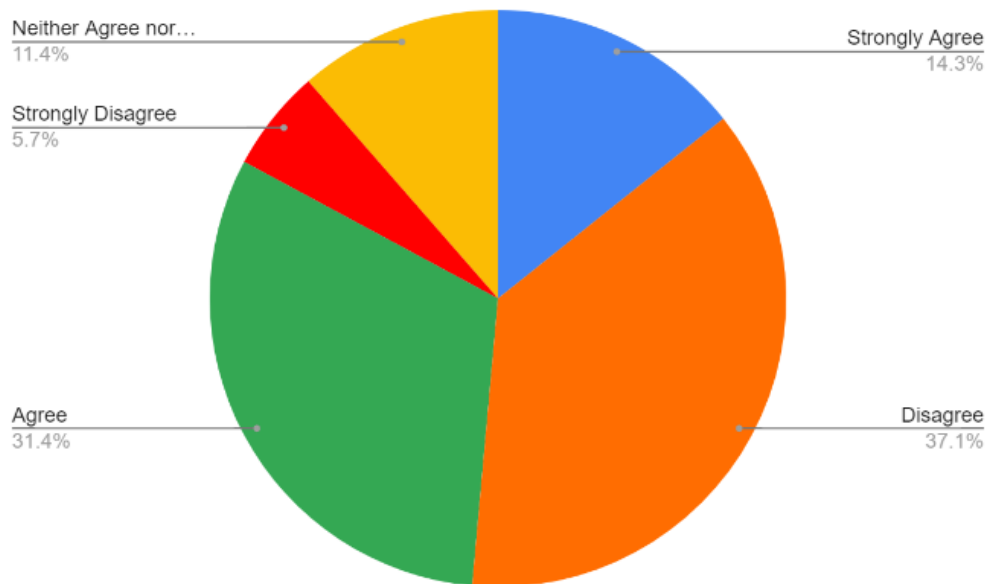
Figure 12 presents an insight into the familiarity and usage of XR tools amongst the trainers. According to the responses, over 80% of the respondents have used VR technologies in comparison to the other XR tools. This also resonates with the responses of the trainee and sailing seafarers. Further, around 30% of the respondents have familiarity with AR technologies and less than 15% of the respondents have used other technologies. Currently, VR and AR are the most prominent of all the XR technologies and this is reflected with the responses of the trainees and the trainers.

Figure 12:XR technologies usage-trainers



The frequency of usage of XR technologies at METIs, through the perspective of trainers, is presented in figure 13. The METIs are trying to adopt the use of XR technologies and over 45% of the respondents agreed that XR technologies are being frequently used at their METIs. However, over 37% of the respondents disagree that XR has started to be frequently used at their METIs and around 5.7% of the respondents strongly disagree that XR technologies are used frequently at their METIs, which can lead to a perception that few MTIs are facing challenges to embrace the XR tools.

Figure 13: Frequency of XR usage-trainers



4.3: Applicability of STCW Competencies and Courses

4.3.1: Perspective of Trainees and Sailing Seafarers

Through the analysis, it is noted that XR technologies would benefit all the levels of competencies including management, operational and support levels, with the most positive impact to the operational level of STCW competency. For the purpose of understanding the impact it would have on the pre-sea training, even the pre-sea level were added as an option in the questionnaire along with the 3 levels of competencies to get a more holistic understanding. The same was added for understanding the perspective of trainers as well. Figure 14 presents the perspectives of trainee seafarers and sailing seafarers about their view on which level would be most benefitted from the XR technologies. According to the survey, around 70% of the respondents opine that XR technologies would be most beneficial at the pre-sea level. The trainees at the pre-sea level, are the trainee seafarers who would have rarely seen a ship and hence they would not be aware of the ship functions and the various parts and operations

onboard vessels. Hence these XR technologies provide a platform to the trainees to get familiarised with the ship and its operations, in a safe environment.

Figure 14: Beneficiaries level-trainees and sailing seafarers

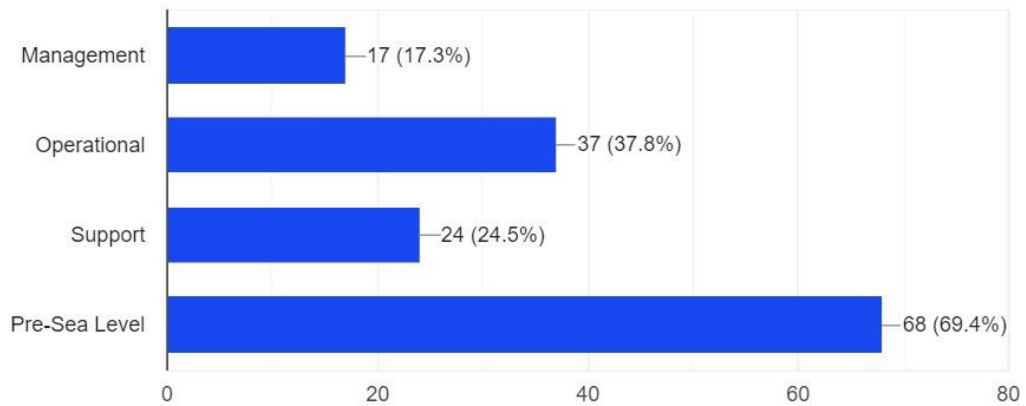
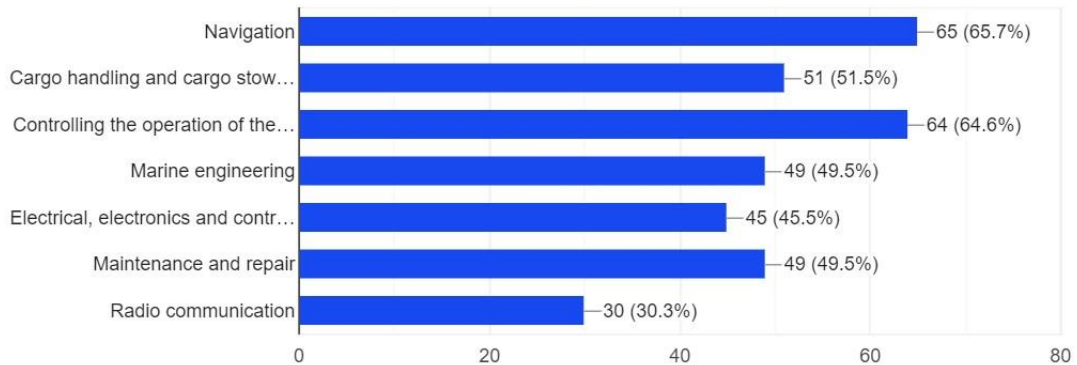


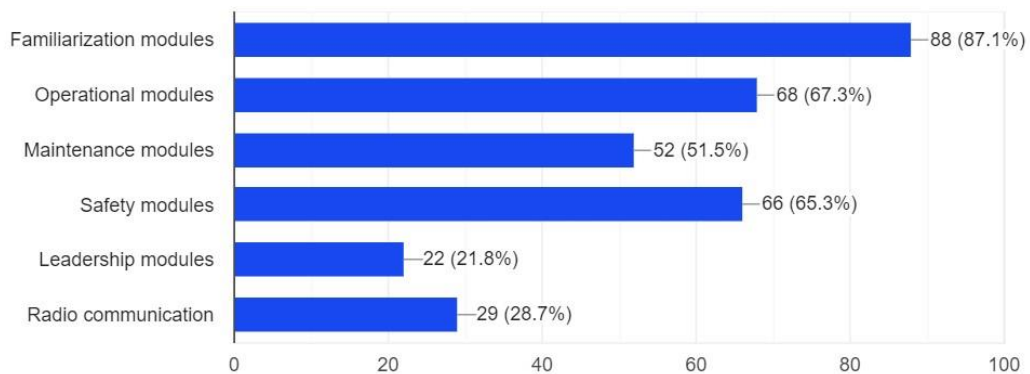
Figure 15 presents the trainees and sailing seafarers' perspectives on which functions will become more effective by using the XR technologies. While the respondents opine that it will cause an impact on all the functions of STCW, over 65% of the respondents perceive that it would have a major impact on the navigation and controlling the operations on the ship and caring for persons onboard functions. Further, only 30% of the respondents opine that these technologies would positively impact the radio communication, hence guiding the technology providers to focus on developing modules towards other STCW functions.

Figure 15: STCW functions- trainees and sailing seafarers



The respondents view it would have an impact on different types of modules including the familiarisation 87.1%, operational modules 67.3%, maintenance modules 51.5%, safety modules 65.3%, leadership modules 21.8% and radio communication modules which is 28.7% illustrated in figure 16. This figure also illustrates the trainee and active seafarer's perspectives on the type of modules required, leveraging the XR technologies. According to the survey, over 85% of the respondents shared a consensus that the familiarisation modules would be more effective, followed by safety and operational modules. Further, parallels are drawn with the applicability of the XR technologies for the various ranks onboard vessels, where the major consensus was for XR technologies being the most impactful at pre-sea level, wherein the trainees have not been onboard any ship and hence familiarisation modules would help better prepare them for being onboard.

Figure 16: Different applicable modules-trainees and sailing seafarers



Figures 17 and 18 illustrate the impact of XR technologies on STCW and value-added courses respectively, through the perspective of trainee and sailing seafarers. Around 50% of the respondents agree that XR would have a positive impact on the STCW courses whereas over 55% of the respondents agree that XR would have a positive impact on the value-added courses. The positive endorsement on value-added courses is perceived to be more since the STCW courses are regulated by the respective administration, which have not yet mandated the use of XR technologies and the METIs and shipping companies have more freedom to use these XR technologies for the value-added courses.

Figure 17:XR impact on STCW courses-trainees and sailing seafarers

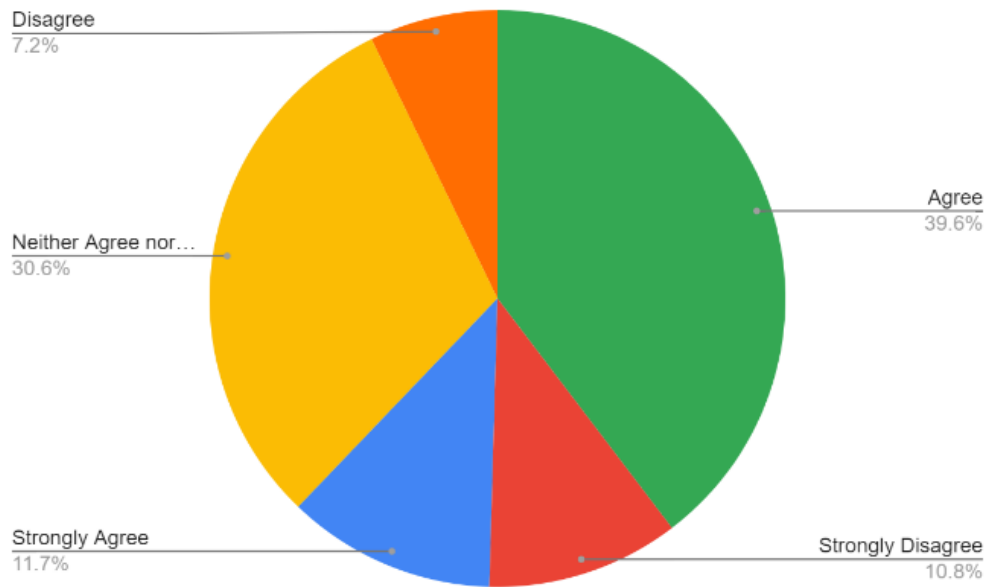
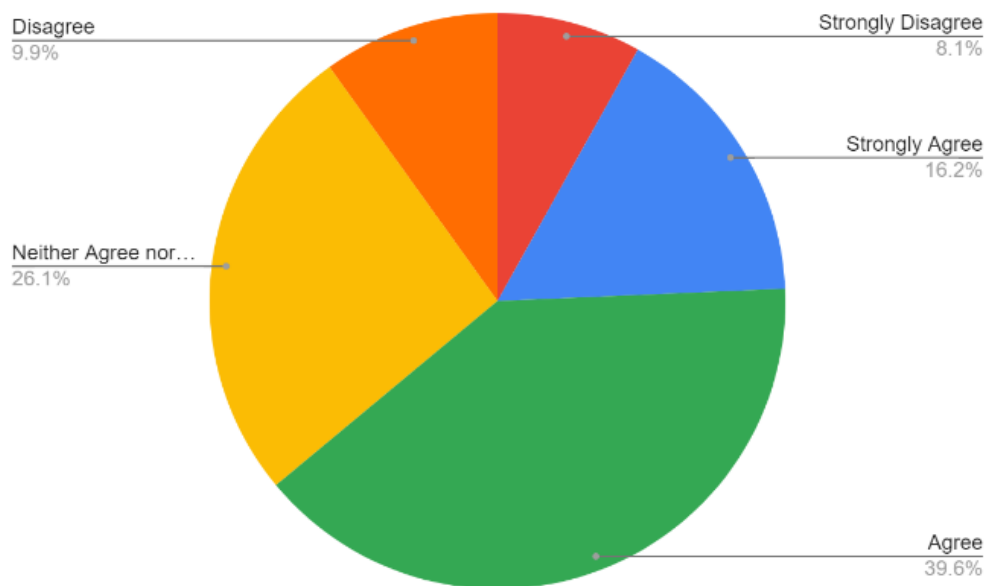


Figure 18:XR impact on value-added courses-trainees and sailing seafarers



4.3.2: Perspective of Trainers

Figure 19 presents the trainer's perspectives about the levels of competency for which XR technologies would be most beneficial. According to the survey, over 70% of the trainers share a consensus that it would be most beneficial for operational level of competency followed by pre-sea trainees. While drawing parallels with the trainee's perspective who opine that XR technologies would be primarily beneficial for pre-sea training, the researcher is able to deduce two schools of thoughts about the usage and importance of XR technologies between the trainers of METIs and the seafarer trainees and active seafarers.

Figure 19: Beneficiaries level-trainers

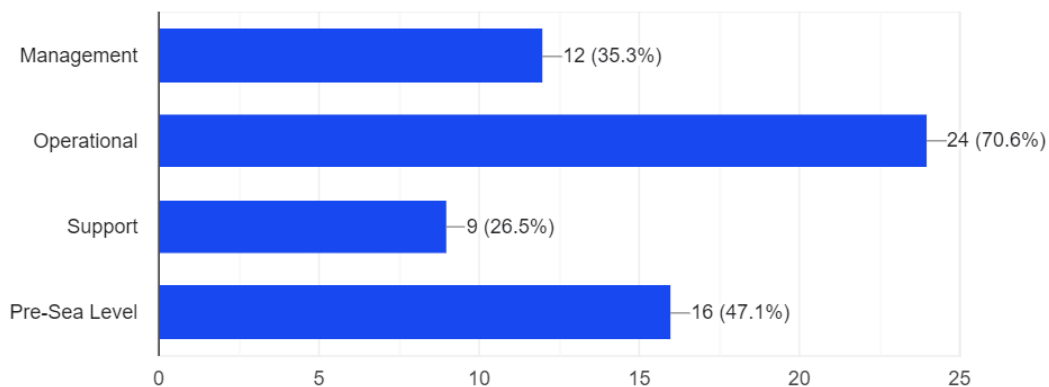


Figure 20 is an insight into the trainer's perspectives of the impact of XR technologies for various STCW functions. Over 70% of the respondents opine that XR tools would be most effective for navigation function followed by cargo handling and cargo stowage function having around 56% consensus. The function of radio communication got the lowest consensus of around 29% which resonates with the perspectives given by the trainee and active seafarers. The trainers view that it will cause an impact on all the functions of STCW and the respondents would have a major impact on the navigation function which account for 70.6%, followed by cargo handling and cargo

stowage being 55.9%, then maintenance and repair being 49.5% & electrical, electronics and controlled engineering being 52.9%, then marine engineering being 50%, then controlling the operations on the ship and caring for persons onboard which is 41.2%, and radio communication being 29.4%.

Figure 20:STCW functions-trainers

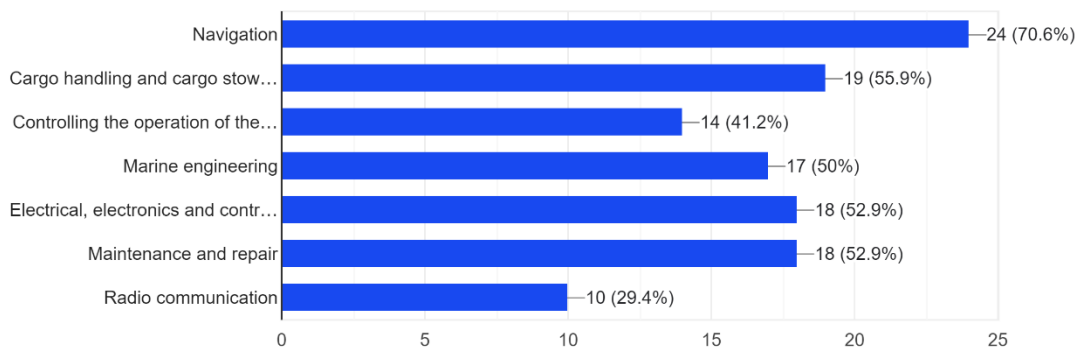
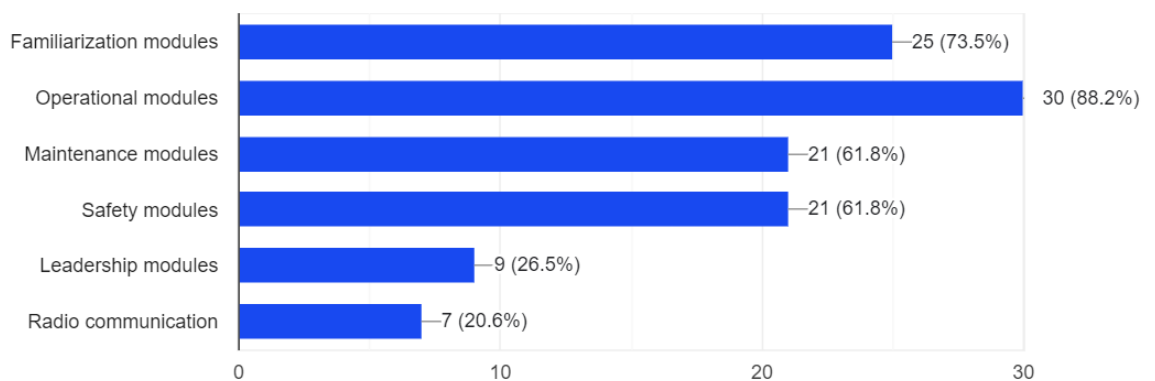


Figure 21 illustrates the trainer’s perspectives on the type of modules that need to be developed by leveraging the XR technologies. Over 88% of the respondents share the consensus that operational modules will be the most effective modules to be developed using XR tools. Further, it’s closely followed by the development of familiarisation modules, which were perceived to be the most important modules to be developed, by trainee and sailing seafarers.

Figure 21:Different applicable modules-trainers



Figures 22 and 23 illustrate the impact of XR technologies on STCW and value-added courses respectively, through the perspective of trainers. Drawing parallels between the perspectives of trainee seafarers and sailing seafarers, and the trainers of different METIs, both the target samples perceive XR to be more impactful for than value-added courses in comparison to STCW courses. Further, over 15% more respondents strongly endorse XR training to have an impact on value-added courses, in comparison to its impact on STCW courses. This leads to a better scope for customised training.

Figure 22:XR impact on STCW courses-trainers

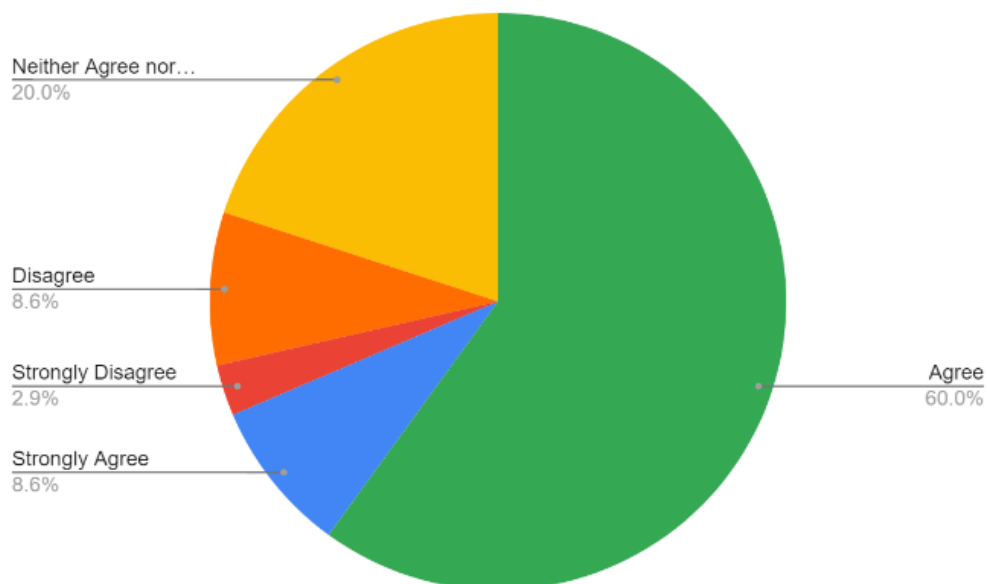
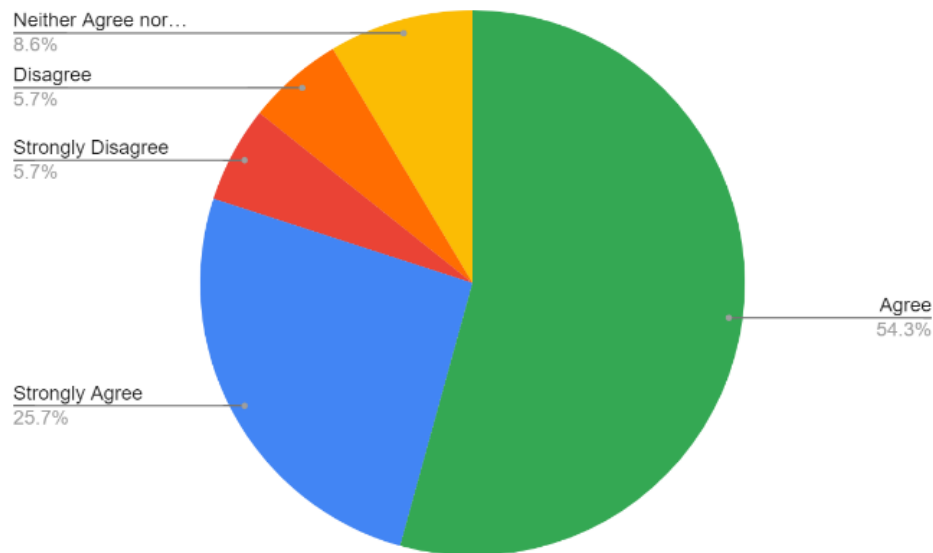


Figure 23: XR impact on value-added courses-trainers

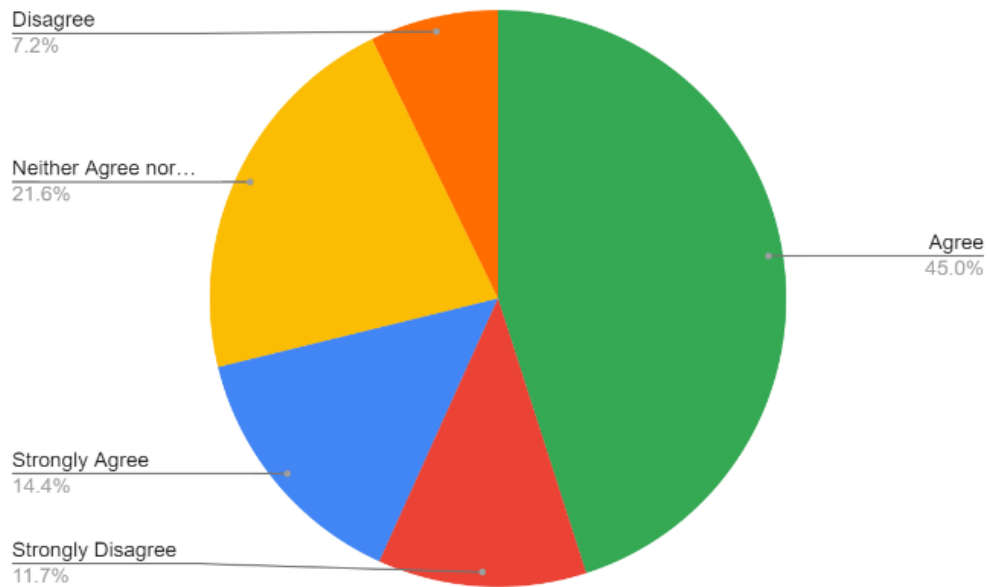


4.4: Benefits and challenges of XR in MET

4.4.1: Perspective of Trainees and Sailing Seafarers

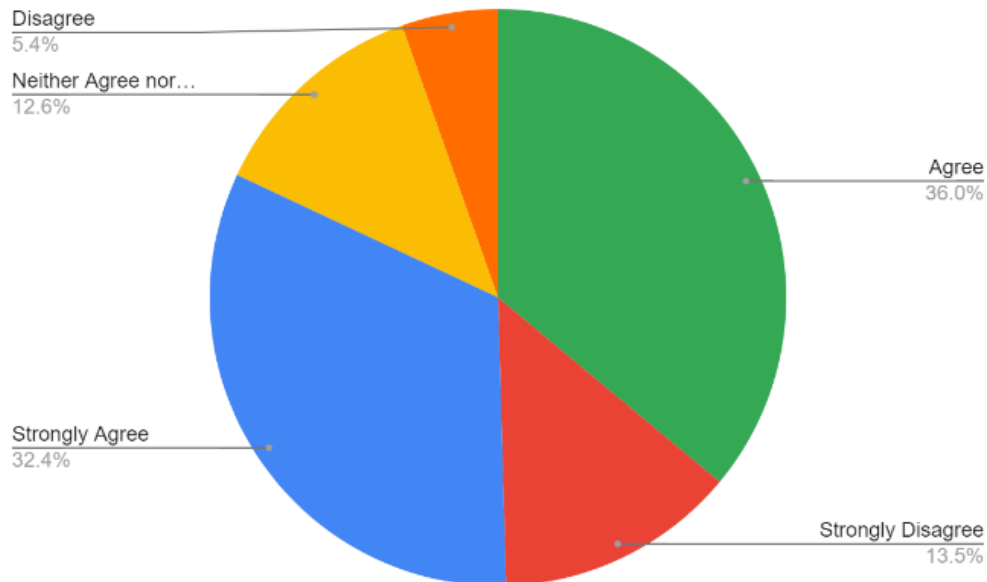
Figure 24 presents the perspective of trainees and sailing seafarers about XR technologies causing a paradigm shift in MET. 45% of the respondents agree and around 15% of the respondents strongly agree to the statement of XR technologies having a potential to cause a paradigm shift in MET. Further, less than 20% of the respondents oppose to the opinion of XR technologies having a potential to cause a paradigm shift in MET. Overall, a stronger positive endorsement to this question reflects confidence to the author about the great benefits and potential of XR tools.

Figure 24: XR would cause a paradigm shift in MET-trainees and sailing seafarers



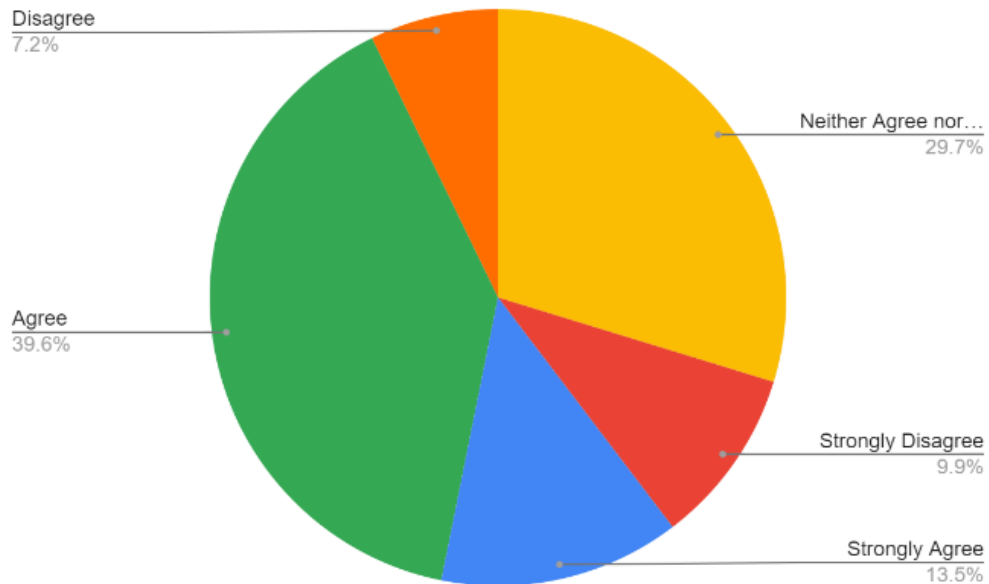
XR technologies have the potential to improve the maritime trainee's safety and performance. As presented in figure 25, around 75% of the respondents positively endorse the potential of XR technologies to improve the safety and performance of seafarers. Further, less than 20% of the respondents disagree about the potential of XR technologies to improve the safety and performance of seafarers. However, the strong positive endorsement reflects the potential of XR technologies to increase the safety levels, improve performance and create a better working ecosystem onboard vessel.

Figure 25: XR would potentially improve maritime trainees' safety and performance- trainees and sailing seafarers



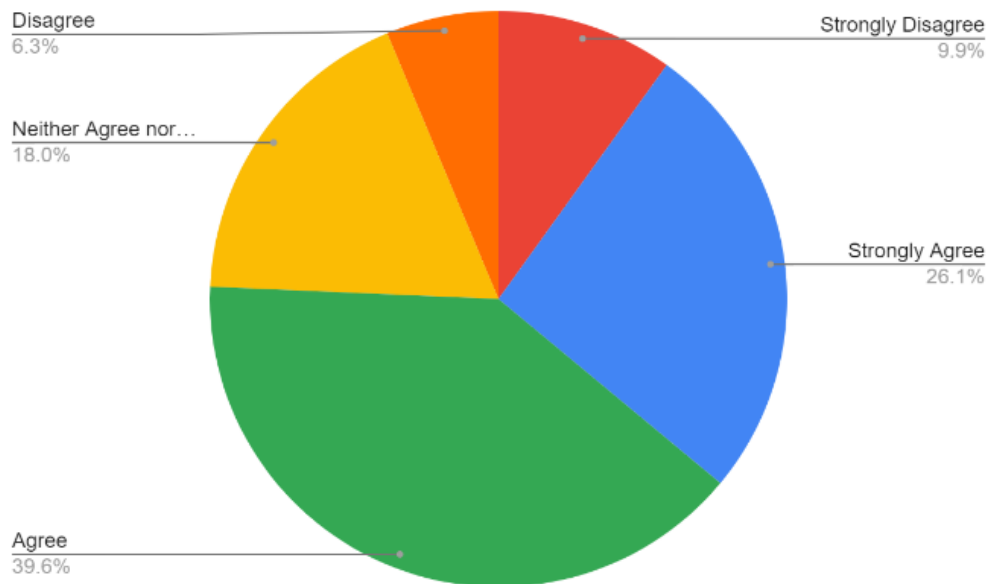
The trainee seafarers and sailing seafarers were asked to share their perspectives about XR training enabling the participants to have better prospects at sea and ashore. Figure 26 presents the survey responses of opinions of value-added training on the XR skills resulting in job prospectus at sea. Around 40% of the respondents agree that their job prospects at sea would increase wherein over 13% of the respondents strongly endorse that statement. Further, less than 20% of the respondents disagree that their job prospects would increase at sea due to the additional training using XR technologies.

Figure 26: Those who receive additional value-added training on the XR skills would have better job prospects at sea-trainees and sailing seafarers



As per the survey, a majority of the seafarers agree to the statement that with the aid of XR technologies, the trainees can enhance their knowledge, understanding and proficiency which would allow them to demonstrate and evaluate their competencies and 39.6% agree and 6.3% disagree indicating a positive endorsement, displayed in figure 27. This indicates that XR technologies would enhance the effectiveness of classroom-based training.

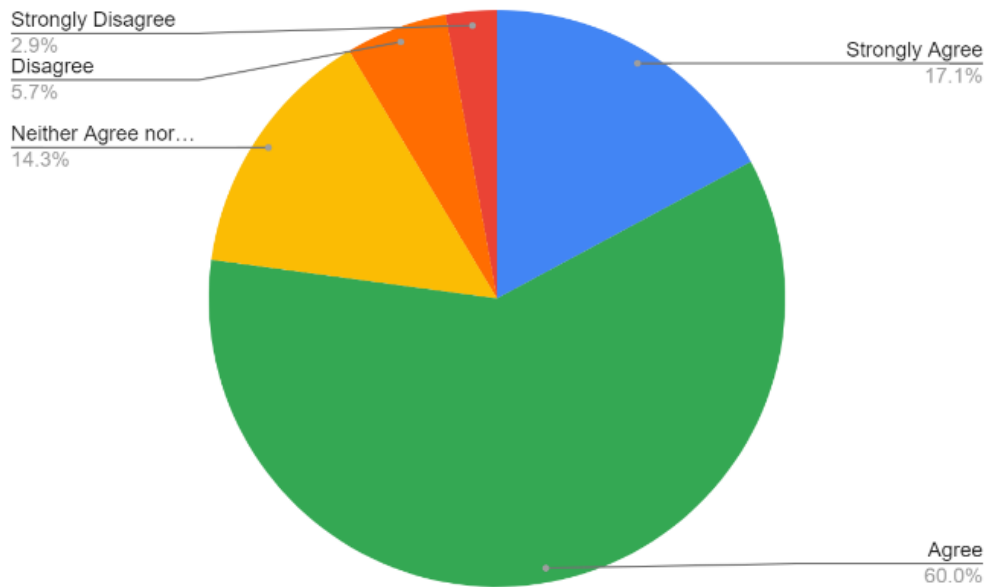
Figure 27:XR would enhance their knowledge, understanding and proficiency, allowing them to demonstrate and evaluate their competence-trainees and sailing seafarers



4.4.2: Perspective of Trainers

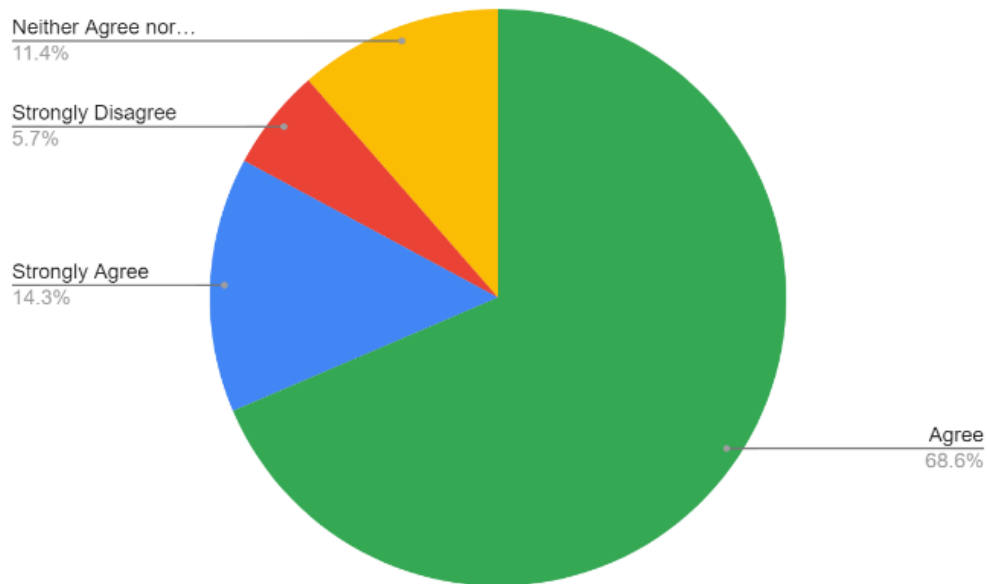
Figure 28 exhibits trainers' perspectives about XR tools having the potential to cause a paradigm shift in MET. As per the responses, over 75% of the trainers positively endorse the above statement. Due to this majority consensus, it's indicated that XR tools hold great potential to disrupt the way teachers teach and students learn, hence causing a paradigm shift in MET.

Figure 28: XR would cause a paradigm shift in MET-trainers



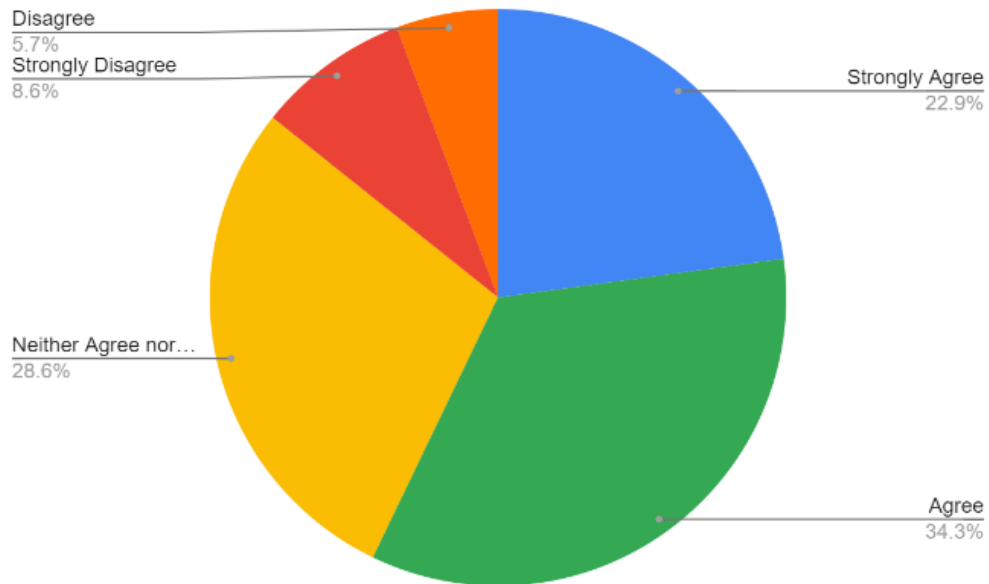
XR technologies have the potential to improve the maritime trainee's safety and performance. As presented in figure 29, around 80% of the respondents positively endorse the potential of XR technologies to improve the safety and performance of seafarers. Further, less than 20% of the respondents disagree about the potential of XR technologies to improve the safety and performance of seafarers. However, the strong positive endorsement reflects the potential of XR technologies to increase the safety levels, improve performance and create a better working ecosystem onboard vessel. This resonates with trainees and the sailing seafarer's perspectives.

Figure 29:XR would potentially improve maritime trainees' safety and performance-trainers



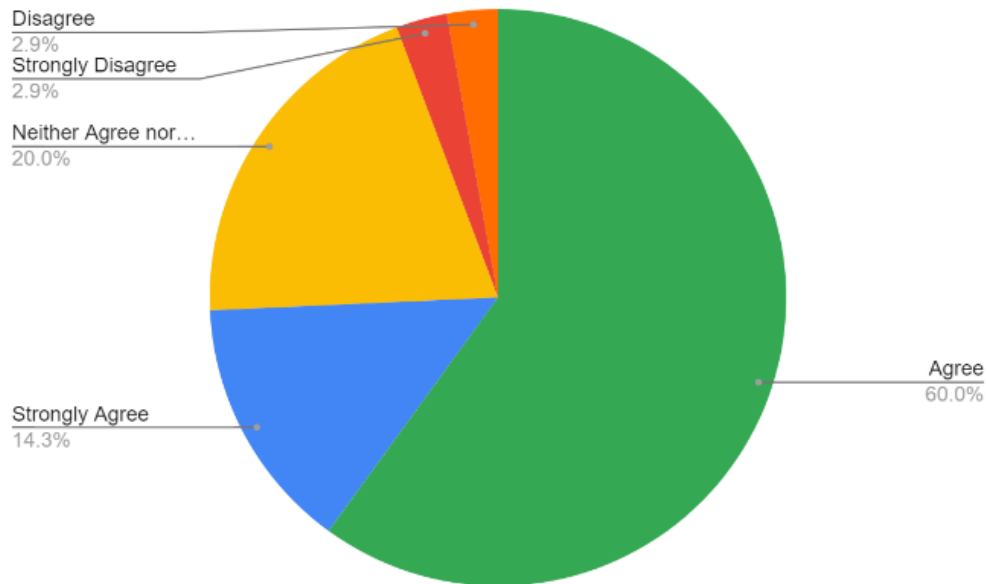
The trainers shared their perspectives about XR training enabling the participants to have better prospects at sea. Figure 30 presents the survey responses of opinions of value-Added training on XR tools resulting in job prospectus at sea. Over 50% of the trainers agree that the trainees who receive additional value-Added training using XR technologies would get better job prospects at sea. This perspective also resonated with the perspectives of trainee and sailing seafarers.

Figure 30: Those who receive additional value-added training on the XR skills would have better job prospectus at sea-trainers



As per figure 31, 60% of the respondents agree that with the aid of XR technologies, the trainees can enhance their knowledge, understanding, and proficiency, allowing them to demonstrate and evaluate their competence and 2.9% strongly agree and disagree with that statement which resonates with the perspectives of the trainees and sailing seafarers.

Figure 31: XR would enhance their knowledge, understanding and proficiency, allowing them to demonstrate and evaluate their competence-trainers



4.5: Chapter Summary

This target sample has experience with XR technologies, which is an opportunity in this research. XR is an emerging concept in the MET, and seafarers are more familiar with VR technologies in comparison to other XR technologies. According to the trainees, the XR technologies are frequently used in the METIs but the trainers believe that there is a greater scope for the use of these technologies in terms of the frequency of usage.

Additionally, the trainees and sailing seafarers believe that XR technologies would be best for pre-sea candidates as they would be able to learn about ships in a safe and controlled setting. However, the trainers believe that operational staff would benefit most from XR technologies since they need to know well about the ships and usage of these technologies would improve the safety levels of the ship. The survey shows that XR technologies can be used for all STCW functions, but navigation, Controlling the

operation of the ship and care for persons onboard & cargo handling and cargo stowage benefit the most. The data suggests that familiarisation and operational modules would have a greater advantage in inducing a value-addition for the seafarers.

The investigation shows that XR technologies would improve the seafarer's safety, performance, and create a conducive environment for training and learning. For ensuring that the seafarers establish their professional competencies they have to undergo various STCW and value-added courses aided by these technologies so that they are competent to perform their onboard duties effectively and efficiently. According to the responses, XR would help seafarers get value-added training which would better their career prospects. This paradigm shift towards XR technologies can benefit the global maritime ecosystem.

Chapter 5: Qualitative Analysis and Findings

5.1: Introduction

The researcher carried out qualitative research by interviewing trainers teaching at different METIs to get a detailed insight into the utilisation, applications, benefits, and challenges of using XR technologies in their METIs. These semi-structured interviews helped the researcher to understand the teaching methods adopted by the trainers using XR technologies. The interviews also provided vital insight into the interviewer's perception and experiences, which contributed to the research.

In this section, the researcher analysed the use of XR technologies across four METIs situated in different parts of India. All the selected METIs are the most prominent METIs in India serving a common goal – to provide quality education to the seafarers. The interviewees helped the researcher to understand the perspectives from different METIs. To maintain ethical standards and confidentiality, Roman Numerals I, II and III were used to indicate the different METIs having the infrastructure of XR technologies which is the opportunity of this research. Additionally, the fourth METI which is in process of setting up their infrastructure for XR technologies was indicated using METI IV.

5.2: Description of the Trainers

A total of five qualified and experienced trainers from four different METIs were interviewed. Out of the five interviewees, four had the necessary infrastructure for conducting training using XR technologies within their METIs. The fifth interviewee's METI was in the process of setting up the necessary infrastructure for XR training and that interviewee's perspective added immense value to the research.

Table 1 indicates the list of trainers with their assigned names and ranks.

Table 1: List of trainers from METIs

METI	Name	Rank	Experience of training in METI (years)
I	Aditya	Master Mariner	7
	Jeet	3 rd Engineer	3
II	Sameer	Master Mariner	12
III	Tushar	Chief Engineer	9
IV	Dev	Radio Officer	6

5.3: Analysis

The research questions were used as lenses to identify common denominators. The result of obtaining data from the NVivo software and manual analysis of the research questions gave the research the common codes which included XR, modules, personalised learning, impact of technology, ship handling, regulatory body, shipping company, safety, customised training and complexities. The themes were derived from these codes to align with the research questions which were categorised into sub-themes. The refined themes included usage of XR, applicability of XR towards the various STCW competencies and courses, benefits and the challenges of this

technologies. The sub-themes included infrastructure of the METIs, education modules, familiarisation, beneficiaries of technologies, impact of STCW, company specific and STCW courses, safety, customised training, economics, breakdown and monitoring, health, realistic scope and maintenance, and adaptability. The research questions were addressed and analysed in the following sections.

5.4: Usage of XR

5.4.1: Infrastructure of METIs

5.4.1.1: METI I

The interviews began with a discussion of METIs, their facilities, and student training. which was elaborated by Aditya and Jeet. METI I offers DGS pre-sea and post-sea training. It also offers value-added courses to Nautical & Engineering students. A world-class futuristic digital lab is set-up at METI I. Further, they have also developed various modules, in-house, ranging from familiarisation on different types of ships to operations in Engineering/Nautical departments and is being used on daily basis. The trainees take turns for using these technologies as per their timetable. The interviewees also mentioned that they have delved into using AR technology and Metaverse. The interviewees suggest that the technology of Metaverse is currently at a nascent stage, but it is an innovative technology that has the potential to create opportunities and accessibilities. They further mentioned that they have established the campus on Decentraland to establish a presence in the virtual space. They are further exploring the potential of MR to enhance the quality of training.

5.4.1.2: METI II

The researcher then interviewed Sameer from METI II. METI II, formed by a shipping company, offers pre-sea, post-sea, and value-added training. Further, Sameer also

suggests that XR training is not a part of the course syllabus, as its not mandated by the administration, hence students are required to complete the various modules recommended by the company. Sameer, further suggests that these modules are used as a value-added training for the students and the company requires the seafarers to complete the certain modules allotted to them. Further, he mentioned that currently, METI II has a suite of 10 Nautical modules in VR and AR training and is in the process of purchasing additional modules for other departments. Further, METI II has world-class simulators and hence XR training acts as a supplementary training. The modules procured by METI II have inbuilt monitoring and assessments wherein each student has a unique login and a time limit to complete the modules before the course completion, which instructors can track.

5.4.1.3: METI III

Tushar from METI III was the next person to be interviewed, and he mentioned that VR training has been adopted by their METI. He also mentioned that the METI embraced this XR during the COVID, which assisted their trainee seafarers in understanding the different components of an engine room. During the pandemic, these technologies replaced the ship visits for the trainee seafarers to get familiarised with the vessels. Tushar stressed on the positive impact VR training has had on the confidence of their trainees who have never been to a ship before. During the interview, Tushar also indicated that the VR training is done in batches wherein each batch goes for VR training in a 2-day rotation, and each student gets trained on the VR for 30 to 60 min in the 2-day period. Further, he stressed that the use of XR technologies is used as a means of value-addition for the seafarers.

5.4.1.4: METI IV

Dev, from METI IV, was interviewed. METI IV conducts various courses for the Nautical and Engineering departments. Dev suggests that while his METI is not using

any XR technologies currently, they are impressed with its potential and are in the process of procuring the necessary infrastructure for XR training. Dev added that their METI is looking for collaborations with Marine Pals and Videotel to explore the impact that these technologies could have on the shipping industry. The interview with Dev was crucial to understanding the reasons for the METI IV to explore the impact of XR technologies in the current training and the potential contributions it can have in future of MET.

5.4.2: Simulation

XR technologies could be perceived as a type of simulator. During the COVID pandemic there was an increase in Computer Based Training (CBT), synchronous training and non-synchronous training. Similarly, when traditional simulators were initially introduced in the market, their functioning was very minimal, but their adoption rose over the years and currently they are a major part of the training. XR tools would change the method and mode of delivery rather than revamping the complete curriculum. Sameer opines that *“once it is recognised by the top and important stakeholders in the industry, it would make a constructive impact on the learning”*. This echoes with Jeet’s perspective who suggests that *“various stakeholders have already started to take initiative making it more popular in the market because it’s creating a positive impact for the students in their learning processes”*. Simulation is crucial to MET because it provides a controlled yet dynamic environment in which students can practice real-world scenarios safely and repeatedly. Aspiring maritime professionals can acquire hands-on experience in complex maritime operations through immersive simulations and situational awareness. This gives the seafarers a rich picture about the operations of the ship.

5.4.3 Education Modules

During the interview, Jeet elaborated on the list of VR modules used for training the cadets in METI I which include:

- Oil Tanker Familiarisation
- Gas Tanker Familiarisation
- LNG Deck Training
- LNG Bridge Familiarisation
- Bulk Carrier Familiarisation
- Engine Control Room Familiarisation
- Working Aloft
- Ro-Ro Vessel Familiarisation
- Air Compressor

Jeet further emphasised that the modules used for VR are also converted and utilised for AR, giving the user a different experience for understanding the topic.

The modules used in METI II are as follows:

- Bridge Navigation and GMDSS
- Bridge Machine and Safety control
- Main Deck Familiarisation
- Aft station Familiarisation
- Forecastle Deck Familiarisation
- Dry Dock Familiarisation
- Fore peak tank: 3rd & Bottom stringer
- Fore peak tank: Chain locker, 1st & 2nd stringer
- Emergency generator startup procedure
- E/R Familiarisation

METI III has a suite of Engineering VR modules. Dev opines that METI IV would be procuring helicopter operations modules & firefighting operations modules in their pilot phase.

5.4.4: Familiarisation

Familiarisation is the initial process for learning the tasks to be performed onboard the vessel and is one of the categories for this research to understand the usage of XR technologies. Aditya suggests that familiarisation is important because it makes the seafarers aware of the operation of ship's equipment specially to be used during any emergency. He further added that these technologies are widely used for "*pre-sea candidates across all the batches as students lack familiarity because they have never seen a ship before*". The three-step learning method- familiarity, understanding the concept and the assessment section can be adopted to ensure the intended learning outcome is achieved. Sameer also shares the same school of thought and suggests that they have developed a wide number of familiarisation modules. Further, Tushar also elaborated that training with these technologies offers a sense of gamification which helps to hook the cadet's attention. Additionally, Dev also added that they are exploring to develop the basic engine room operations and fire-fighting operations. It is implied that the modules are currently adopted majorly for the familiarisation of different types of vessels and machinery.

These modules foster progressive learning, leading to adaptability of shifts in the industry and personalised student engagement. According to Jeet, Metaverse would balance the experiential and engaging learning environments by integrating the VR and AR simulations. This accommodates diverse learning styles and mode of learning.

5.5: Applicability towards STCW Competencies and Courses

5.5.1: Beneficiaries of Technology

Regulatory bodies play an integral role in maintaining the standards, fostering the implementation and the use of new technology into the respective ecosystem, and to monitor the other stakeholders. Technology is leading to the shift in training in view of the new trends in learning. Aditya points that learning is “*switching from the traditional blackboard learning to interactive learning and immersive experiences*”. These technologies boomed during the COVID pandemic and Tushar argued that “*VR training replaced a ship visit and would be helpful during another pandemic*”. Overall, the potential of these technologies is limitless and it’s beneficial for all level of operations, especially at entry levels. Once the technology is more stable and widespread, its benefits would be limitless and fascinating. This would also open the doors for the regulatory bodies to get more clarity on the use of these technologies to improve the quality standards for training their seafarers. These technologies would serve a broad spectrum, from the management level to the pre-sea candidates. During the interviews, the trainers of all four METIs suggested that XR would benefit all the levels of competencies, with the junior levels of training being the primary focus. This perspective resonates with the analysis of the survey of the trainee and sailing seafarers who shared the consensus that XR tools would be mostly beneficial for pre-sea candidates.

5.5.2: Importance of STCW

Government of India has ratified the STCW Convention, and DGS governs the Indian METIs to meet the minimum requirements laid down by the convention. Aditya suggested that the administrations meet the minimum STCW requirements and suggests that there should be few amendments in the STCW to incorporate various XR

tools so that these technologies can be embraced by other METIs. This perspective resonates with Jeet's insight into the revisions of the STCW. Further, even Sameer, Tushar and Dev share the same school of thought and suggest that once the STCW includes these immersive technologies for training, then the administration can enforce these technologies. Hence, STCW has to be revised for the administration to take action, otherwise, it would only be depended on the contributions made by the shipping companies and a few METIs. According to Tushar, minor revisions in the STCW would currently suffice to get a wider adoption to meet the training requirements of the future and also views that the trainers would need to upskill to provide quality training to the students. Sameer and Dev share the same opinion as Tushar. However, Aditya proposes a major amendment and suggests that XR has the potential to be the frontier in simulation, and simulators form a big part in MET. This concept is supported by Jeet. Based on the gathered information it's noted that XR technologies have the potential to be a part of, and catalyse the subsequent STCW amendments.

5.5.3: Company specific and STCW courses

Through the analysis of the semi-structured interviews, it is deduced that the various XR modules is currently used as a value-added training. Until mandated by the administration, these training modules are specific to each company's requirements. For instance, training modules for tankers and different types of engines for different ships could be developed and used. Tushar suggests that for the higher levels of competencies, such as the management level, XR technologies should be more detailed, for instance overhauling in 3 dimensions. Aditya also suggested that XR is limited to the user's imagination, and having a team of capable people would able the conversion of the imagination into real-life actual scenarios and gave an example that another company approached his METI to simulate an incident report for the management level officers.

Further, during the interview, Aditya argued that these Modules can also be used for cargo operations and expresses that “*people sail in different types of vessels and having worn a VR set a tanker man (who sail on liquid cargo ships) can understand the functioning of a bulk carrier and container ships too. It would even be beneficial for the master who has no experience on polar ships indicating that VR can create different scenarios and have a look on icebreaker vessels*”. Further, certain activities such as imaginary modules can be developed like celestial navigation and be loaded into a VR set making a planetarium to understand the concept of celestial navigation and the cargo operations.

Sameer views XR technologies would be most beneficial for the navigation and the cargo handling and stowage function, compared to other functions, as the variables such as the weather, sea-state, current prevailing, or navigational hazards can be simulated more effectively in VR. Similarly, in cargo operations, there are many variables, such as the crane operations and the loading/ discharge sequence in tankers including the effect of the vessel’s stability and stress levels.

Dev put forward his views that as ECDIS brought a revolution, and paper charts are getting phased off, similarly, XR tools will help organisations to familiarise their crew /officers with different type of ships, equipment and machinery onboard vessels, before boarding. Further, Jeet emphasised that these technologies have the potential to enhance the operating skills of seafarers prior to them actually operating the live equipment on board. They can learn about the operations of safety items such as lifeboats, fire extinguishers, and other safety gears.

We can conclude XR would be beneficial for ship-specific courses or value-added courses for the initial phases. Further, the application of these technologies would scale to wide range of courses including value-added such as modified scenarios & hazard identification, engine room components identification & operations, cargo operations and navigation. Additionally, XR can encompass critical modules like overhauling of

purifiers, pumps, compressors, main engine, generators and other auxiliaries installed onboard. Once there are few amendments to the STCW convention and enhancement in the recognition, it would drive all METIs will adopt these technologies. This can augment the traditional teaching methods with XR technologies for other STCW courses like basic safety & security training and tanker familiarisation course.

5.6: Benefits of XR in MET

5.6.1: Safety

As per the analysis of survey in the previous chapter there is a positive endorsement amongst the respondents that the XR technologies have the potential to improve the safety of seafarers. MET modules promote effective learning outcomes by catering to individual needs, aligning with global quality standards and enhancing the safety aspects. The use of XR tools results in improving the quality, as it has the potential to enhance the performance of the student thereby increasing the safety by equipping them with the ability to experience high risk environments and operations in a safe and controlled environment. According to Jeet and Aditya, AR and VR technologies can even simulate highly crucial operations giving few instances such as the “*high voltage equipment, working aloft, enclosed space entry and mooring operations where many accidents occur*”. Further, Tushar suggests that emergency conditions can be recreated using these technologies such as the operation of the emergency generator and CO2 flooding system in the event of a fire. Sameer also added that crucial operations such as fighting the fire, lifeboat lowering, emergency steering operations which improve the safety levels of the seafarers working onboard can be simulated effectively using XR technologies.

5.6.2: Customised Training

The modules can be customised to meet the learning objectives of a specific course. For instance, giving the trainee a walk-through experience of different modules across different weather and sea conditions on different types of ships. XR training is more efficient as the trainees get immersed into the virtual environment allowing the users to get a 360-degree visualisation. Further, Tushar points out that XR technologies equip the learner to go beyond 2D videos and to understand the function of every machinery, the nomenclature of the various parts of the ships, including symbols, call points, pumps & valves location, etc. Tushar further suggested that the students get an *“in- depth experience of the engine room equipment and the complete engine room as a whole which is about 4 to 5 floors depending on the type of the ship”*.

Aditya added that his colleague works in one of the largest ship management companies, on the verge of acquiring 15-20 new sister vessels. He further added that all the new crew needs to be trained for safe operations on board the ship, and considering those training factors, a *“model of one ship can be created and that same kind can be replicated across all the other ships”*. He further added that this would allow the crew to get a feel of what is there on the bridge and other equipment’s even before they leave for the shipyard. So, typically a takeover party spends at least three-four days to figure out the equipment and functions of the machinery. This can result in saving of man-hours for joining crew of 20 vessels. The above statement is a testament to the potential of these technologies to not only improve the safety levels but also save the numerous work hours, thereby explaining the importance of customised training. Tushar concludes by suggesting that XR is the future of training and even a milestone in the training for the era of autonomous shipping.

5.6.3: Economics

The financial implications in any industry play a vital role in ensuring the smooth functioning of operations. One of the key benefits of XR is its affordability in comparison to physical simulators. The capital investments required for these XR simulators is much lesser in comparison to the traditional simulators which require multiple screens while serving the same purpose. Dev points out that “*it would be more economical and more realism in comparison to traditional simulators*” and Tushar points out that the “*financials for the training of these students are lower and a time saviour for the students*” and all other interviewees share the same opinion.

5.7: Challenges of XR in MET

5.7.1: Breakdown and Monitoring

While XR is a promising technology, they could face few barriers. A prominent roadblock is the technical issues which include connection issues or streaming lags. Further, they could also have a breakdown in the middle of performing the task since the ship modules have heavy files due to extreme detailing. However, Aditya views the breakdown also as a positive impact on learning and suggests that the students have to re-do the tasks, enabling them to learn the topic once again, eventually enhancing their knowledge. Another challenge with the XR technologies is that some trainees would consider these tools similar to video games and would need constant monitoring to make the training session more effective. This was also concurred by all the interviewees.

5.7.2: Health

The next challenge identified is the health impact due to the prolonged usage of these XR tools. Currently, the XR technologies like VR and AR are in the nascent stage and hence a user could wear the VR/AR headsets only for a limited amount of time after which they could get headache, motion sickness, or affect their eyesight. Aditya suggests that the “*eye sight plays an integral role to clear the medicals to serve at sea*”, and hence many METIs might be reluctant to adopt these technologies at this juncture. Sameer argues that prolonged usage of these technologies can lead to fatigue. However, he is optimistic since the number of headsets have been increasing and with the entrance of big firms like Apple into this industry, the quality of headsets would improve, helping users to wear the headsets for longer periods.

5.7.3: Realistic scope and Maintenance

The next challenge is the quality of the modules created. All the modules need to have a high resolution and should be as realistic as possible to make the experience more immersive for the user. Currently, these modules face a challenge due to resolution, since a higher resolution would result in a higher file size which would increase the lag while operating the module. Jeet also added, that an efficient IT team should be kept in place to carry out the maintenance of the systems and ensure that the robust cybersecurity system is in place to comply with the national and international data protection laws, which resonates with the Sameer’s view.

5.7.4: Adaptability

The learning curve for the senior faculty is observed as a key challenge. Dev suggested that the experienced senior level seafarers have the technical expertise but are not able to adapt and use these technologies to the full extent. Hence, the respective METIs

need to conduct Faculty Development Programs and regular training sessions. Aditya and Jeet also emphasised that many faculty at their METI were reluctant at the start to use these technologies. To tackle that, they added VR training in the course timetable and provided multiple training sessions to the faculty which made the faculty more confident.

5.8: Chapter Summary

XR technologies are currently in the building-up stage and can be the frontier of simulation in the near future. XR technologies can help the learners understand the various components of the bridge and engine room. These technologies can serve a broad spectrum and be most beneficial for pre-sea candidates. Further, the usage of these technologies is currently limited to company requirements. However, once the awareness is raised, they can scale and provide a wide range of courses, including mandatory courses as a part of STCW. There are many benefits of using XR technologies, such as the ease of use in different environments, being more affordable compared to the traditional simulators, and, most importantly, recreating the critical and risky operations onboard the ship to make the learner more aware and confident to perform the task. While there are certain drawbacks, in the near future, many challenges can be mitigated by increasing the quality and bringing more advanced equipment into the market. It is perceived that XR training will follow the adoption journey of traditional simulators and over time become a key milestone in Indian Maritime Training.

Chapter 6: Conclusion and Recommendations

6.1: Conclusions

XR is amongst the most promising technologies and has the potential to cause a paradigm shift in an industry. Through previous studies, it was apparent that multiple industries across the world have begun exploring the XR technologies, due to their tangible benefits. However, the research of XR within the MET industry is limited. Dewan et al. (2023), point out that these technologies draw fresh attention to the traditional classroom setting and emphasise the need to enhance the awareness and utilisation of XR in MET. It is required to investigate the implementation and large-scale utilisation of these technologies to achieve a more effective learning outcome for MET. This is the overall gap that this research has addressed. This study facilitated a deeper understanding of the usage of the XR technologies within the MET framework. Further, this study took an exploration of the application of XR technologies in context of STCW and determine the benefits and challenges of XR in the MET using India as a case study.

Based on the analysis of the findings, it's interpreted that VR is more widely explored amongst the other XR technologies. It is also observed that, the current usage of AR, MR and Metaverse in METIs is limited, as the technologies are still nascent. However, as these technologies are advancing, there is a potential for increasing the frequency of usage in the METIs to make it more effective for large-scale utilisation. Upon

analysing the data, it is observed that XR is currently utilised only as a means of value-addition in the METIs and is used to train the candidates for company-specific courses, as the regulatory bodies in India have still not mandated the usage of these technologies. The in-depth examination of the findings also revealed that the majority of the XR modules currently developed are targeted towards the familiarisation of different types of vessels and machinery. It is also noted that METIs should encourage using these XR technologies so that candidates have a competitive edge and are more familiar with the vessels and its machinery. The evidence through the interviews further suggests that there will be a wider adoption and usage of XR once it is recognised by the regulatory bodies.

As examined through the interview, XR technologies can be utilised in a wide range of courses including value-added courses like the identification and operations of the components in the engine room, cargo operations, navigation & hazard identification, and emergency procedures. A rise in the awareness of the use of such technologies can be scaled to STCW courses, especially the basic courses like basic safety and security training, and tanker familiarisation. Once there are amendments to the STCW convention, or in the directives by the administration, to mandate the use of XR technologies, all METIs will have to embrace these technologies. Hence, the limited use of XR can expand into wide-scale usage after it is mandated by the regulatory bodies.

Based on the data gathered from the qualitative and quantitative analysis, it is indicated that XR can be beneficial for all levels of STCW competencies, especially the lower levels of competency. Additionally, through a deeper analysis of the interviews, it is observed that it can primarily benefit the pre-sea trainees the most due to the lack of familiarity, as they are unaware about the different parts of the vessel. This perspective resonates with the analysis of the survey of the trainee and sailing seafarers, where a majority of the respondents shared a common consensus that XR tools will be primarily beneficial for pre-sea candidates.

Further, through the analysis of the survey, it is indicated that XR technologies will have a greater impact on the navigation, controlling the operations on the ship and caring for persons onboard & cargo handling and cargo stowage functions of STCW. Based on the analysis it can be concluded that there is certainly a need for amendments in the STCW convention in view of the emerging XR technologies. There are however different schools of thoughts between the maritime professionals, with few suggesting a major and a few believing that a minor amendment will suffice.

Based on the analysis, it is revealed that XR technologies have the potential to improve the performance of seafarers and create a conducive environment for working onboard. It provides flexible and cost-efficient training solutions in MET adding to the personal development of the individual, which is in line with the discussion done in the previous studies. Additionally, XR technologies can catalyse a paradigm shift in MET due to the enhancement of learning experiences and tailoring courses for customised training. The XR technologies can be useful in recreating and simulating the operations on ships, especially the critical operations, which can improve the seafarers' understanding of the familiarity, operations, maintenance and above all, the safety aspects of the vessel.

Based on analysis, several challenges were identified; one of such challenges of XR is that it can cause headache, motion sickness and even affect the eyesight if used continuously for a longer duration which is also affirmed by Bhardwaj et al. (2022). Further, through the interviews, it was highlighted that XR can have technical issues due to connectivity and hence constant monitoring will be required for more effectiveness and uninterrupted learning. Another challenge is that these technologies currently need to be accepted by trainers at METIs, as they might lack the technical expertise to embrace these technologies to their full potential. It was also observed from the interviews that a technical team, including cybersecurity experts, will have to be hired to maintain the XR infrastructure.

In conclusion, this research targeted the stakeholders having the knowledge about the XR technologies, which is an opportunity in the research. XR technologies have the potential to add immense value to the MET as it can create immersive and interactive experiences by simulating crucial operations onboard, thereby easing the process of learning. This paradigm shift in adopting XR technologies can create a positive impact on the entire maritime ecosystem.

6.2: Recommendations

The future scope of research is to encompass other METIs in India, who have not explored setting up the infrastructure for XR training. Additionally, it would be vital to explore the usage of XR technologies to analyse participant behaviour during emergencies. Currently, out of all the XR technologies, VR is predominantly used by METIs, and hence it is integral to research the extensive impact of AR, MR, and Metaverse in MET. Further, additional research must be conducted for identifying the training gaps for the trainers and develop courses to upskill them to effectively implement these technologies. The research can also be done on the impact of XR technologies in training and handling of autonomous and remote-controlled ships.

It is also recommended that research can be conducted to understand the perspective of other stakeholders such as the members of administration and ship owners with regards to the adoption of XR technologies. The research could also explore the utilisation of XR across METIs around the world, especially across the major seafarer-supplying nations like the Philippines, China, and Indonesia, and to compare its effectiveness at a global level.

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Appendices

Appendix 1: Consent Form

Consent Form

Dear Respondent, thank you for your valuable time to respond to this survey. Your contribution to this research work is highly appreciated. I am currently studying to earn a post-graduate degree in Maritime Affairs at the World Maritime University, Malmo. As part of my dissertation, I am seeking to gather information from seafarers, on their view and benefits on the applications of XR. I would be extremely grateful if you could kindly take some time out and assist me in gathering the necessary data for my research by answering the attached questionnaire. Responding to this questionnaire should not take more than 5-10 minutes. All the information gathered will be treated with utmost confidentiality, and will be used strictly for academic purposes only. All research related data will be stored on the Google Drive during the survey and then deleted after completion of the course. Your response to this questionnaire indicates your voluntary and informed consent to participate in the survey. Your participation in this research is entirely voluntary, and you have every right not to participate in the survey or withdraw at any stage. However, I sincerely hope that you will participate by responding to the questionnaire and help me in the completion of the research, which would be a great contribution to the METIs across the world in training.

Each respondent was given a consent form to fill out and return.

The following was included on the consent form:

- All data collected would be used solely for academic purposes.
- All data collected will be stored on a google drive and deleted after the degree is earned.
- The participant has the right to refuse participation in the survey at any time. The procedures and tools used in this investigation were authorised by the World Maritime University Research Ethics Committee.

Appendix 2: Questionnaire to Trainees and Sailing Seafarers

Dear Respondent,

Greetings!

I am currently doing research in the area of the application and future scope of extended reality in Maritime Education and Training (MET). As a part of my research work, I wish to seek information from the experience stakeholders in the shipping industry and therefore request your valuable time and patience in answering the following questionnaire to the best of your knowledge. Your honest opinion will greatly help me in my research and also in improving the approach to the future of Maritime Education and Training to meet the latest industry requirements. All the information gathered will be treated with the utmost confidentiality and will be used strictly for academic purposes only. Thanks in advance for devoting your valuable time to answering this questionnaire.

With warm Regards

Tirth. S. Vakil

World Maritime University

I. Email

Your email address

II. Name (Optional)

III. Age:

- A) Below 20
- B) 20-25
- C) 26-35
- D) Above 35 years

QUESTIONS:

- 1) Which responsibility level describes your current or most recent role in the seafaring industry?
 - A) Management level
 - B) Operational level
 - C) Support level
 - D) pre-sea level

- 2) Which Department are you associated with?
 - A) Nautical
 - B) Engineering
 - C) Catering
 - D) ETO
 - E) Others

- 3) Which Extended Reality (XR) technologies have you used personally?
 - A) Virtual Reality (VR)
 - B) Augmented Reality (AR)
 - C) Mixed Reality (MR)
 - D) Metaverse
 - E) All of the above

- 4) What is your level of familiarity with XR?
 - A) Extremely familiar
 - B) Very Familiar
 - C) Somewhat Familiar
 - D) Not Very Familiar
 - E) Not at all familiar

- 5) XR tools will cause a paradigm shift in Maritime Education and Training.
 - A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree
 - E) Strongly Agree

- 6) XR tools can potentially improve maritime trainees' safety and performance.
 - A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree

- E) Strongly Agree
- 7) XR training tools are frequently used at my institution.
- A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree
 - E) Strongly Agree
- 8) The future of marine education and training is in XR tools.
- A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree
 - E) Strongly Agree
- 9) With the aid of XR technologies, the trainees can enhance their knowledge, understanding, and proficiency, allowing them to demonstrate and evaluate their competence.
- A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree
 - E) Strongly Agree
- 10) Major amendments to the STCW convention are expected because of XR technology.
- A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree
 - E) Strongly Agree
- 11) XR tools will cause minor amendments in the STCW convention.
- A) Strongly Disagree
 - B) Disagree
 - C) Neither Agree nor Disagree
 - D) Agree
 - E) Strongly Agree
- 12) Trainees should have greater access to XR for training-related activities.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

13) XR could provide customised training programs.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

14) Trainees will find it difficult to adapt to the use of XR.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

15) Malfunctioning of XR tools will impact the effectiveness of training.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

16) The current trend of XR in Maritime Education and Training is promising.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

17) The competency levels which will have impact due to usage of XR in Maritime Education and Training are:

- A) Management
- B) Operational
- C) Support
- D) pre-sea level

18) It will cause an impact, especially in the training of STCW courses.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

19) It will cause an impact, especially in the training of Value added / Company Specific courses.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

20) Which of the following functions of STCW would XR create a major impact?

- A) Navigation.
- B) Cargo handling and cargo stowage.
- C) Controlling the operation of the ship and care for persons onboard.
- D) Marine engineering.
- E) Electrical, electronics and control engineering.
- F) Maintenance and repair.
- G) Radio communication.

21) XR Technology would help the trainee in the following:

- A) Familiarisation modules
- B) Operational modules
- C) Maintenance modules
- D) Safety modules
- E) Leadership modules

22) Please rate your overall experience after using XR Tools

- A) Very dissatisfied
- B) dissatisfied
- C) Neutral
- D) Satisfied
- E) Very Satisfied

23) How much of your understanding on operations have improved before and after undergoing simulator training

- A) Above 90%
- B) 75-90%

- C) 25- 50%
- D) 10-25%
- E) Less than 10%

24) Those who receive additional value added training on the XR skills would have better job prospectus at Sea

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

25) Those who receive additional value-added training on the XR skills would have better job prospectus ashore.

- A) Strongly Disagree
- B) Disagree
- C) Neither Agree nor Disagree
- D) Agree
- E) Strongly Agree

27) Any other questions you feel pertinent to be addressed as regards XR in Maritime Education and Training

Appendix 3: Questionnaire to Trainers

Dear Respondent,

Greetings!

I am currently doing research in the area of the application and future scope of extended reality in Maritime Education and Training (MET). As a part of my research work, I wish to seek information from the experience stakeholders in the shipping industry and therefore request your valuable time and patience in answering the following questionnaire to the best of your knowledge. Your honest opinion will greatly help me in my research and also in improving the approach to the future of Maritime Education and Training to meet the latest industry requirements. All the information gathered will be treated with the utmost confidentiality and will be used strictly for academic purposes only. Thanks in advance for devoting your valuable time to answering this questionnaire.

With warm Regards

Tirth. S. Vakil

World Maritime University

I. Email

Your email address

II. Name (Optional)

III. Age:

- A) Below 20
- B) 20-25
- C) 26-35
- D) Above 35 years

- IV. How many years of teaching experience do you have?
- A) Less than 1 Year
 - B) 1-2 Years
 - C) 2-5 Years
 - D) 5-10 Years
 - E) More than 10 Years

All the other questions are similar to the Questionnaire which was distributed to the trainees and sailing seafarers.

Appendix 4: Interview Questions

Dear Respondent,

Greetings!

I am currently researching in the area of the application and future scope of extended reality in Maritime Education and Training (MET). As a part of my research work, I wish to seek information from the experience stakeholders in the shipping industry and therefore request your valuable time and patience in answering the following questionnaire to the best of your knowledge. Your honest opinion will greatly help me in my research and also in improving the approach to the future of Maritime Education and Training to meet the latest industry requirements. All the information gathered will be treated with the utmost confidentiality and will be used strictly for academic purposes only. It will be collected through the use of semi-structured interview data collection targeting the trainers of the METIs. The following questions stated below would be the basis of the questions and would be open to follow-up questions during the interview.

Thanks in advance for devoting your valuable time to answering this interview.

With Warm Regards

Tirth. S. Vakil

World Maritime University

Thanks for your valuable time to take part in the interview and guide me in my Research and answering few questions:

- 1) Which Training Institute are you teaching for?
- 2) Does Your Training Institute have the technology for Extended Reality (XR)?
- 3) What XR technologies are being used in your METI?
- 4) Elaborate the designing and opportunities for these technologies?
- 5) How frequently do you use XR?
- 6) XR is used for conducting which courses in your training institute?

- 7)What competency levels do you think will cause an impact in MET?
- 8)What do you think are the potential benefits of XR in MET?
- 9)What do you think are the challenges of using XR in MET?
- 10)What according to you is the current trend of XR in MET?
- 11)What are your predictions for the use of XR for the future of MET?
- 12)What role do you think the regulatory body should be playing in supporting the use of XR in MET?
- 13)What were the feedback from students after using the XR tools?
- 14) How do you achieve the learning objectives for the use of these technologies?