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Maritime Education and Training in the COVID-19 Era and Beyond

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ABSTRACT: The rapid global spread of COVID–19 has created numerous challenges for educational organizations of all levels around the world. Maritime Education and Training (MET) institutions are no exception and have faced major disruptions from the pandemic. Differing technological and organizational solutions have had to be quickly adapted in short timeframes in order to fill gaps and ensure continued teaching and learning. Although online education is nothing new, COVID-19 has accelerated the necessity for distributed learning, digital tools and infrastructure needed to not only cope, but excel in the restructuring of MET. In this article we present our experiences from the blended course offered to maritime bachelor students at our university in Norway through a case study. The findings from the study have revealed that although blended learning has helped continued education during the pandemic, it still has to overcome general as well as MET specific challenges to be successful in future. Considering the impact and challenges of the COVID-19 pandemic on MET, we further discuss the short-term responses and possible long-term solutions that can contribute to uninterrupted, high-quality learning for future MET. The use of emerging technologies for education, such as virtual reality (VR) and web-based training simulators, are likely to play an essential role in the future direction of MET.

1 INTRODUCTION

Throughout the global spread of the COVID-19 virus (scientifically referred to as the severe acute respiratory syndrome–coronavirus 2 or SARS-CoV-2), educational institutions have scrambled to find new methods and approaches for enabling the uninterrupted delivery of education across varying degrees of lockdown and social distancing protocols. The partial or full lockdown of societies and new social interaction protocols are changing cultural norms in the effort to prevent the spread of the COVID-19 virus. These measures have had significant consequences for Maritime Education and Training (MET) stakeholders and the maritime industry as a whole. Results from a recent survey conducted by International Association of Maritime Universities (IAMU) have reported that 93% of its member universities are affected to their normal education activities [22]. The pandemic has forced them to look into alternative ways of delivering their educational content [3]. For MET facilities, teachers and students, this has meant a departure from the typical deployment of education and training methods due to: (1) fully closed and/or restricted access to physical facilities (e.g. classrooms, simulators and other facilities); (2) physical gatherings and interpersonal interaction of large numbers of students, teachers and staff in close proximity have become a public health risk; (3) typical MET facilities and training programs were not designed or have taken into account the requirements for recent social distancing protocols; or

(4) staying home for work and study has been generally advised and recommended in order to adhere to evolving social distancing protocols and to reduce opportunities for infection. These challenges introduced by the rapid spread of COVID-19 have accelerated the need for innovative education and training solutions.

Among the many challenges imposed by the COVID-19 pandemic are shifts in how educational content is delivered, with a migration away from the traditional in-classroom experience to more technology-based virtual learning experiences. Prior to the global spread of COVID-19, MET was already transitioning towards an increased use of digitalized solutions, such as e-learning, for new students and cadets looking to enter the industry, but also for professional training and re-training across the maritime domain. Due to the inherent nature of the profession, seafarers cannot participate in classroom teaching for continued education and training as easily as personnel in centralized shore-based professions. Information Communication Technologies (ICT) have created new opportunities to extend the learning and training environment. Whether to onboard ships or other marine structures, which may be located in remote, physically inaccessible environments, or to the trainee's own home, eliminating the need for travel and its associated resources. Because of this, blended learning approaches were adapted to enhance the accessibility of training material for remote training. For example, trainees attend a blended learning course starting with traditional classroom teaching followed by individual study using digital material and a web-based learning environment [17, 25].

The proliferation of the pandemic has forced the maritime domain and MET to adapt sooner than planned or anticipated, fast-tracking many solutions which were already in development or used, though to a lesser degree, prior to 2020. For example, differing approaches under investigation, and in use, in the education and training of maritime trainees inherently employ social distancing practices, such as e-learning and online assessment [6, 26, 41], remote simulator training [7] and Virtual Reality-based simulators [34]. There are also efforts within maritime education community to have joint simulation learning platform available to connect different maritime education and training providers [16]. In a previous, pre-COVID-19 published article the authors reviewed the applications of immersive technologies, such as virtual and augmented reality in MET and discussed the advantages of distributed, remote training through them [28]. Utilization of these remote training methodologies using emergent technologies has become more important now than ever before. Typical remote training methods can range from relatively basic audio and video-based communication, lecturing and online learning portals to more advanced web-based 3D and VR-based simulators with real-time interactions and communication [3].

Considering the above, a transformative change of the current maritime educational approach is inevitable and necessary. It is important now that all stakeholders of MET, including training institutions, maritime policy makers and curriculum planners, from basic training to specialized courses, must critically reflect on the present situation and make appropriate decisions about shaping the future of MET. In this article, we present an interim solution we adopted for teaching for a bachelor's course and results from the case study towards students' perception of the solution. We also discuss specific challenges of COVID-19 in relation to MET and explore different alternatives for uninterrupted delivery of MET. For this, we consider the concept of technology-supported distance learning as a plausible solution and discuss the future pedagogical and infrastructure requirements from MET facilities, teachers, and student's perspective. This is relevant not only for mitigating the effects of COVID-19 or other future small or large-scale pandemics on our educational system, but for the organization and deployment of future education as a whole.

2 BACKGROUND

2.1 *The Impact of COVID-19*

The COVID-19 pandemic has had an enormous impact on the global education sector and has created significant challenges for the higher education community. It has caused schools and universities to close, either fully or partially, due to local, regional, national and international lockdowns to varying degrees and durations. Social distancing and self-isolation measures implemented to slow the virus spread have included closing of schools and universities by reorganizing teaching and learning activities from remote locations, such as one's home, for both teachers and students. In many countries, at least with those of adequate network infrastructure, the immediate response to the need to close the physical campuses of higher education institutions was to rely as much as possible on distance learning [49]. Moving all teaching and learning activities online has created various immediate challenges, such as technical (internet availability, bandwidth quality, device availability and compatibility, etc.), individual (digital competence, motivation, etc.), social [40] and pedagogical challenges [27]. COVID-19 has required higher education institutions to reimagine how they deliver learning experiences to their students and required utilization of technology to deliver continued education. It is too early to predict the long-term effects, however relying on Educational Technology and online infrastructure appears to be a viable option for educational institutions. This however brings unique challenges for MET where access to educational tools and infrastructure, such as training simulators are imperative for knowledge acquisition and an integral part of the seafarer education and training [36].

2.2 *Roles of education institutes in MET*

Historically, the maritime industry has relied upon apprenticeship and informal, unstructured learning gained through experience onboard ships as the means of acquiring maritime competencies for its workforce [29]. This apprenticeship model promoted learning skills and knowledge acquisition in the social and functional context. With the introduction and adaptation of Standards of Training, Certification and Watchkeeping (STCW) convention amongst most maritime nations in 1978, MET has transformed from the informal apprenticeship model to a more formal, structured and internationally unified education with defined learning outcomes for certification and promotion [39, 48]. With the adaptation of the STCW, school-based vocational education has become the standard for MET.

The STCW advocates a combination of traditional schooling and on-the-job training for MET. METs curriculum now follows both theory-based education (i.e., classroom, textbook, theory) and practice-based education (i.e., hands-on experience via (i) simulators and (ii) at-sea). The content and learning outcomes of MET have evolved over the years, but education and training seafarers revolves around a combination of (i) theoretical knowledge, typically gained through traditional lectures, studying and testing; (ii) practical experience and training, gained through simulator training and real-world practical experience at sea [39].

Figure 1. Students training in maritime simulators (Image copyright: USN)

2.3 *Simulators in maritime education*

Simulators have evolved to become an increasingly integral part of MET and seafarer certification since they were first introduced in the 1950s [36]. Simulators have been utilized to fulfil the need for training students and professionals for safety critical work tasks. Early bridge simulators were used for training technical skills, such as radar plotting, passage planning and basic ship-handling [19]. Engine Room simulators were first introduced in the 1980s, followed by cargo control room simulators for other ship operations and cargo handling training [18]. Today, simulators are used across various aspects of the maritime industry for training, from teaching technical skills for bridge and engine operations, fire safety and emergency response, crane and winch operations, cargo handling, to non-technical skills, such as bridge and crew resource management training [45]. In addition, simulators are used for the training of highly specialized operations, such as dynamic positioning and anchor handling for offshore operations. Simulators bypass the safety implications and associated costs of on-the-job training and provide the benefits of repetitive learning in a realistic, safe and controlled environment [20, 35, 47]. MET simulators have varying levels of fidelity and technical sophistication, ranging from small single equipment task trainers to full mission engine room and 360-degree view bridge simulators integrating simulation software with realistic physics engines, real-world equipment hardware and recreated wave motions, as experienced at sea [43]. The importance of simulators for MET is well recognized by the IMO and the role of simulator is incorporated in the STCW (STCW/95) and its subsequent amendments [39].

3 MET AND COVID-19: ISSUES AND SOLUTIONS

The closing down of physical education and training locations due to COVID-19 and the implementation of strict infection control measures, such as limited physical access to onsite facilities and avoiding shared equipment usage, have limited the opportunities for the students and teachers to utilize traditional MET infrastructure. With simulators being integral to MET, access challenges to these facilities have significant consequences on how education and training is deployed, and ultimately the learning outcomes of students. This is also one of the unique challenges of distance education for MET, as it is requisite for the students to gain hands-on knowledge and skills from these learning tools, such as traditional training simulators which are typically only accessed in centralized facilities.

3.1 *Online learning*

The immediate response to the COVID-19 pandemic is the increased adoption of online technologies that are available for education. One of the most affordable and quick solutions was to utilize existing ICT solutions, adapt online platforms, and Video Conferencing Systems (VCS) for delivering lectures. COVID-19 developed and spread at a time when the education sector could more easily and effectively adapt to the demands of societal lockdowns and physical distancing than at any point in previous decades. IT infrastructure, digital communication, video conferencing systems, online learning management platforms have all been previously integrated into post-secondary and professional education culture for many years. Thus, the transition from traditional post-secondary and professional educational paradigms of physical presence of both instructor(s) and student(s), or a blend of physical and digital solutions, was arguably easier and more successful for all parties due to the already established technological infrastructure and collective experience of using such systems by the community. This is particularly evident if contrasted with a similar hypothetical global event or outbreak of the magnitude of COVID-19 occurring even a decade previously, let alone pre-2000.

Online learning emerged in the 1990’s and has since proliferated as a disruptive pedagogic tool that challenged the then “norms” of traditional education paradigms [1]. Although e-learning and online platforms for pedagogical applications have been utilized for over twenty years, the traditional model for education of in-class and on-campus pedagogic activities endures. Whether lectures, workshops, laboratory sessions or group work, involving physical face-to-face instructor-student interactions, and peer student-student interactions continued to be the norm throughout the 21st century. Online students enjoy benefits of learning at their own pace and the flexibility of learning from distance and it accommodates students from far away to participate in the learning activities. This is because online learning provides an opportunity for asynchronous learning. Asynchronous learning is learning where students and teachers are not bound to a specific place and time [21]. At the same time, online learning has some disadvantages compared to traditional learning. This includes the lower efficiency of the learning process due to lack of direct contact and the impossibility of applying a personal approach of teaching to each student [42]. Hrastinski [21] further states that students might feel isolated during online learning and not part of a social learning group, which is crucial for collaboration and learning. However, with events such as the COVID-19 pandemic, online learning becomes an important driver for success. Despite the limitations of online learning, such as slow learning outcomes, difficulty in seeking advice from teachers, and collaboration challenges, online learning is one of the most viable options for continuing education considering the current situation.

Many MET institutions have utilized online platforms for continuing the learning during lockdown. Online learning is categorized into two types: asynchronous and synchronous learning (Figure 2). Asynchronous are self-paced online learning methods that are the most common e-learning methods, such as the MOOC. Material for asynchronous learning include digital reading materials, lecture slides, and video recordings of the lectures. Online learning management platforms are utilized to distribute the learning material and communication platforms, such as email, messaging, social media are utilized for keep the communication going. Synchronous on the other hand is commonly supported by media such as webinars, video conferencing and live chat. Live lecturing, through online platforms offers the opportunity for instant communication between the lecturer and student, as in a live classroom lecture.

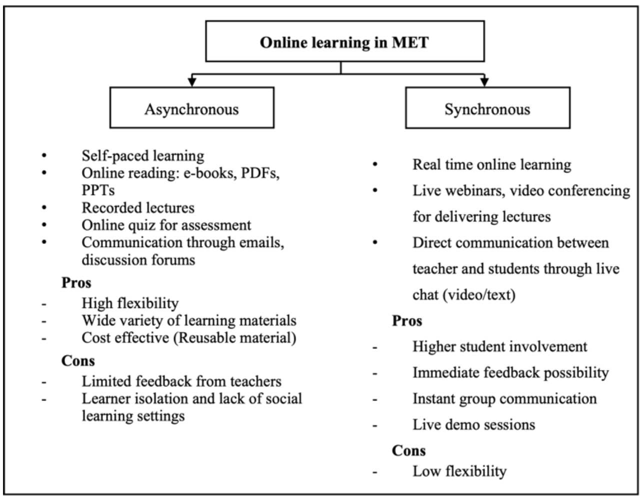

Figure 2. Online learning in MET

3.2 *Blended learning*

When the online educational materials and opportunities for interaction online are combined with traditional place-based classroom methods, it solves many of the problems related to online learning. This pedagogical approach is called blended learning (BL). Blended learning requires the physical presence of both teacher and student at some part of the course, while the rest of the course have the convenience and flexibility of the online knowledge delivery.

4 BLENDED LEARNING COURSE IN MET: A CASE STUDY

4.1 *Navigation passage planning, bridge organisation and communication course*

Due to the COVID-19 pandemic related lockdowns, a blended course approach was implemented for some of the courses at the Bachelor of Nautical Science degree at our university located in the south-eastern part of Norway. One such course is the Navigation passage planning, bridge organisation and communication course, taught in the fourth of six semesters. The course module covers the Global Maritime Distress and Safety System (GMDSS) and serves to extend the students' knowledge, understanding, and proficiency in Maritime Mobile Radio and Satellite Communication.

The course is required for certification as a GMDSS radio operator and a prerequisite to get a General Operator Certificate (GOC), which is mandatory before applying for a STCW Deck Officer Certificate.

The duration of the course is one semester: 14 weeks with two school hours face-to-face classroom lectures and four hours (45 minutes) practical training using communications simulator or real-life radio and satellite equipment with instructor present in both sections.

To achieve the Telenor's subject plan recommendation of 100 working hours for the course, 70-80 % attendance was set as mandatory for the final GOC-exam. The activities taken into use in this course are videos, quizzes, scenarios, problem-based learning, role-plays, simulator training, and drills on real equipment.

The Learning Management System – the university uses a learning management system (LMS) called Canvas. The Canvas LMS enables teachers and students to communicate and offers a wide variety of options to enhance the teaching and learning process.

External Videos - In the Canvas modules, links for YouTube videos introducing subject matters were shared to get students "connected" onto the context before the lectures starts.

Quizzes – each module of the course was ended with quizzes covering the subject matter. The quizzes were designed to activate the students by working individually or in groups. The immediate score after answering the quiz give self-assessment, feedback on satisfactory achievement of the learning outcomes. During the COVID-19, peers worked with the quizzes digitally using the digital meeting program Zoom. Dividing the class into breakout rooms with set bridge teams, students prepared for a compulsory Telenor part exam.

Instruction videos – subject responsible teachers at the university produced instruction videos that are available at Canvas. The instruction videos were produced first in 2015. This was followed with three new versions in April 2021, due to the upgrading of the fixed radio and satellite equipment. The videos give short and practical descriptions in how to solve tasks as GOC operator.

Problem based learning- Each practical training session in the Radiolab consists of working to figure out how to solve problems.

Simulator training- Using the simulator students learn communication procedures and familiarize themselves with the radio and satellite equipment. To do drills helps remembering actions and procedures, as to practice SAR- exercises on VHF or Inmarsat C on the simulator.

Real life equipment training- Using real life VHF, MF, HF equipment students can communicate outside the campus, doing weekly procedures as radio check with Coastal Radio South, sending e-mails from Inmarsat C or Iridium satellite equipment, communicate with ships in vicinity to do radio checks. Having three fully equipped radio bridges students get training on how to familiarize when embarking new vessels later in their career. The ability to interpret technical diagrams and to recognize the schemes physically in the radio is part of the training. The students also communicate in-between the radio stations at campus, knowing outsiders can hear the communication gives an extra fidelity and nerve into the drill. A "bridge" with a remote alarm panel, silent alarm (SSAS) an ECDIS and AIS shows the interconnectedness between different equipment as the GNSS, AIS and VHF. Switching between the different power sources – batteries or ship main or emergency generator are to be practiced real life.

Using scenarios and role play - While preparing for the oral practical exam, students play the role of the internal, external sensors and the candidate giving peer assessment reviews.

Constructive alignment- The course design focus on the importance of constructive alignment [4]. To highlight the connection between teaching, student activities) during the course (giving formative assessment) and the final exam (the summative assessment).

4.2 *Study*

The purpose of this case study was to investigate whether increased BL due to the COVID-19 restrictions had satisfactory effects on student learning. The study seeks to identify elements of BL that worked and elements that were not perceived satisfactory by the students and teachers. BL is not a singular phenomenon but rather a combination of methods using technology and effective face-to-face teaching and learning strategies. In this case, the BL had to be adapted for remote learning while campus has been closed to stop the spread of COVID-19 pandemic. Although better than stoppage of teaching and learning during the lock down, investigating the effectiveness of the BL approach and sharing the experiences from the blended teaching will be useful for future development of such courses. With these nuances under consideration, we aim to answer three main research questions:

- RQ1.What effect, if any, does an increase in the degree of BL implementation during COVID-19 pandemic have on student learning on the bachelor level maritime course?
- RQ2.What aspects of BL are perceived as most effective by students?
- RQ3.What aspect of the BL are perceived as least effective by the students and teachers?

A qualitative case study approach was adopted to answer the research questions. We gathered the experiences of the students in the transformed maritime communication course under the COVID-19 pandemic and explored the potential impact of different instructional decisions (such as online communication synchrony, flipped approach, digital technologies used) on the perceived satisfaction of the students enrolled in the bachelor of nautical science degree. A seven-point Likert like scale (see appendix) was used to gather student perceptions post the final examination regarding the flexibility, quality of the course, learner satisfaction and appropriateness of the technology used in the course followed by a short interview.

4.3 *Results/Findings*

Data was collected from a total of 35 students (32 male and 3 female students, mean age: 24.1, SD 3.92) who participated in the course. The results from the questionnaire are presented below,

4.3.1 *BL course flexibility*

When it comes to the flexibility of the course, students agreed that the blended format course allowed them to arrange their work more effectively save more time for other activities (Q1, Q3 and Q6). However, they didn't agree that the advantages of the course outweighed the disadvantages (Q2).

Table 1. Responses on BL course flexibility

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Mean	4.1	3.1	4.7	3.2	4.1	4.7	3.2	2.8
StDv	1.4	1.4	1.5	1.4	1.5	1.5	1.6	1.1
Median	5.0	3.7	5.0	3.0	4.0	5.0	3.3	3.0

4.3.2 *BL course quality*

When it comes to the quality of the course, majority of the students agreed that the quality of the course was unaffected by the blended format (Q11). At the same time there was huge variance observed in the responses of the students.

Table 2. Responses on BL course quality

	Q9	Q10	Q11
Mean	3.6	3.0	4.6
StDv	1.5	1.4	1.7
Median	4.2	3.1	5.0

4.3.3 *Perceived learner satisfaction and Technology appropriateness*

When it comes to satisfaction, the students could neither agree nor disagree on the decision to choosing the course in the blended format (Q12, Q16). This is mainly because there wasn't an option since it was forced due to the COVID-19 situation. However, they agreed that it served their needs well (Q14) considering the situation. Also, there was a general disagreement when it comes to choosing the course in the blended format voluntarily (Q13, Q15). At the same time there was a high agreement between the students regarding the technology used for knowledge delivery (Q17).

Table 3. Responses on learner satisfaction and tech. appropriateness

	Q12	Q13	Q14	Q15	Q16	Q17	
Mean	3.4	2.8	4.8	2.9	3.7	5.77	
StDv	1.5	1.1	1.6	1.3	1.5	1.31	
Median	3.8	3.1	5.0	3.0	4.0	6	

The results show some clear trends in student perceptions about different aspects of the blended course format. The subsequent interview provided further insight into these responses. For example, students like the flexibility the BL course offers, but there were also high individual differences noticed in the responses. Some students enjoyed the comfort of learning from anywhere while some missed the structured learning opportunities at the classroom. The individual characteristics of the students should be considered for gaining further insight.

Almost all interviewed students agreed to the importance of the course and quality of the teaching provided. The main factors that affected the response score were students didn't like watching theoretical lectures provided online and the lack of opportunities for hands-on exercises.

It was clear from the interviews that the most effective aspects of the course were practical exercise performed at the lab and the least effective aspects were theoretical lecture provided online. Many students complained about the isolation during online lecture and lack of peer interaction and communication with the teacher during the lecture. Overall, the findings revealed that the students had a mixed experience with the BL course offered.

5 THE FUTURE OF MET: COVID-19 AND BEYOND

The case study confirmed that one of the major challenges for MET is to replicate the experience of simulator and on-the-job training while practicing social distancing. Currently available technologies, such as e-learning, online lectures, videos are utilized as a quick solution for continuing education. For the theoretical aspects of MET, these solutions would be adequate if implemented properly. However, the practice-based curriculum of MET will be impossible to provide online with these existing technologies. Keeping this in mind, we consider different scenarios for continuing MET in the future and associated challenges with each of scenarios, whether in its traditional, digital or BL approaches. Figure 3 presents a spectrum of knowledge delivery methods in MET. Before the pandemic, knowledge delivery and practices were performed in physical classrooms and shared simulators facilities. In addition, Learning Management Systems (LMS) were widely used in higher education institutes for distributing materials, scheduling, monitoring, reporting learning activities, and for communication between students and teachers. COVID-19 forced the educational institutes to move the physical classrooms to online through video lecturing where possible. However, due the nature of the curriculum, several courses and programs may find video lecturing inadequate for many learning objectives. This has led some schools to start utilizing web-based simulators for remote practical exercises for teaching during the pandemic [44]. At the same time the efficacy of web-based simulators for training and assessment is yet to be proven. The following sections discuss the possible future scenarios for the MET.

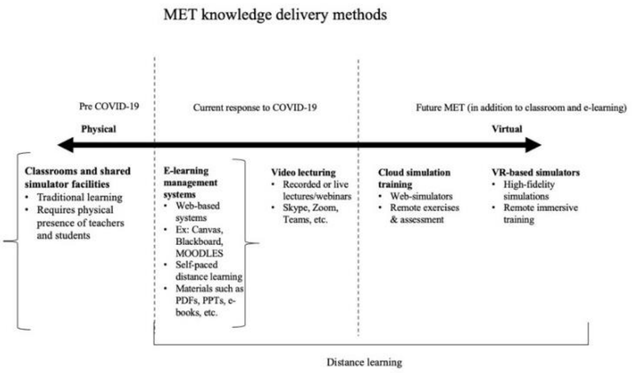

Figure 3. Spectrum of MET knowledge delivery methods pre and post COVID-19

5.1 *Shared training facilities*

The most immediate solution is the reopening of educational institutions and simulator training facilities for students with new usage protocols. Local regions and nations that have successfully contained the virus spread have begun to reopen educational institutions already. For MET institutions, this means following strict hygiene practices and using personal protective equipment (PPE), limiting users of the facilities in any given time and maintaining social distancing protocols. For example, reducing the size of practical classes is carried out by scheduling more sessions with a smaller number of students. This solution requires increased resources from the institution, in the form of increased human resources for teaching (i.e., more teachers and/or teaching and administration hours) and facility cleaning (i.e. more custodians and/or custodian hours), as well as for consumable PPE and disinfectant products (e.g. disposable masks, gloves, hand and surface disinfectant, etc.). However, these solutions are only feasible if the facility and region in question is capable of implementing such practices both from a regional or national governance perspective, as well as the practical resources and capabilities of an institution's budget. Furthermore, a new local or national outbreak around the location of the training facility could push the institutions back into lockdown. Thus, adopting a modified pre-pandemic approach to MET, although feasible in some situations, is not the most resilient option.

5.2 *Technology-assisted distance learning*

The term "technology-rich learning environments" refers to settings in which teachers and students use technologies for various educational purposes and applications [9]. The previous two decades saw MET institutions integrating net-based learning solutions into the teaching both in campus-based as well as the blended learning courses. The Internet, as an education medium, has enabled new ways for teachers, students and administrators to share information, resources and communicate, creating new ecosystems in how education is designed, deployed and utilized by all parties. The concept of distance learning today refers predominantly to the use of web-based online learning. Emerging ICT solutions have become highly attractive for distance teaching as they offer solutions to the several barriers in traditional distance learning. For example, they have the potential to reduce the loneliness of scattered students by providing social interaction with teachers and peers; to provide easy access to libraries and other information resources which was difficult before; and to update the study materials regularly [15]. With these solutions, digitalised distance learning is more relevant for the MET, and education in general, now than ever before. If we consider the models of technology-rich learning environments in higher education put forth by Fossland [10], the learning settings at MET utilised both "campus models" and "blended models II" pre-COVID-19 (see Figure 4). COVID-19-related restrictions have directed the synchronous campus model to blended model I, which predominantly consisted of online lectures and delivery of educational content. However, in order to be fully independent of physical location constraints and any future external forces and restrictions imposed by local, regional or global events, MET must consider increasingly organizing courses and programs towards blended and online models. As seen throughout 2020 and into 2021, MET institutions and programs scrambled to reorganize ongoing future educational programs towards these models in order to cope in the short term. However, as we move forward, both the technological infrastructure and resources, as well as human resources and skills (e.g. students, teachers, administrators, etc.) must have inherent flexibility and resilience in order to adapt to evolving situations which require differing models of educational deployment.

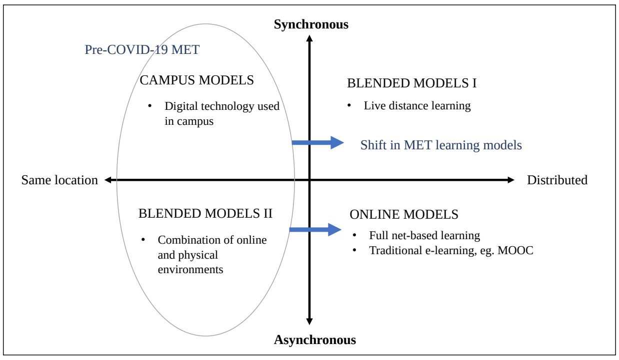

Figure 4. Models of technology-rich learning settings [10]

Paulsen [32] proposed the jigsaw model to define the 4 differing systems that are required to work together in order to support effective online learning (See Figure 5): (i) Content Creation Tools (CCT) are used by course designers and teachers to create the content in online education courses; (ii) Learning Management Systems (LMS) are web-based software packages that enable administration, documentation, tracking, reporting, automation and delivery of educational courses, training programs, or learning and development programs (iii) Student Management Systems (SMS) for the management of information about entities, such as students, faculty, courses, applications, admissions, payment, exams, and grades; and (iv) The Accounting Systems (AS) record the economic transactions between the stakeholders of online education.

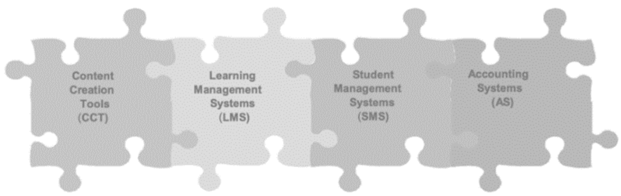

Figure 5. The jigsaw model for online learning [32]

The scope of this article focuses on the impact of technology on CCT and LMS. As emerging individual technologies evolve to change how education is delivered to students (through the LMS), so to do they affect how classes, courses and programs are organized and deployed by teachers (through the CCT). In the efforts to redesign teaching and learning, MET must balance and align curriculum, instruction, and assessment with the instructional technology features and the mediums employed. As an increasing array of technological solutions become available, creating new opportunities for both in-person and distance learning requires that these components be synchronized and evaluated with particular attention paid to the educational objectives and principles of learning [13]. Technology capabilities are now allowing traditional education and MET LMS, such as online platforms for file sharing, video lecturing, student-student and student-instructor interaction, to more sophisticated web-based simulators and Virtual Reality (VR) applications for individual and team training exercises [30]. This is enabling new opportunities for blended models and online models.

5.3 *Use of emergent technologies*

As previously discussed, MET requires more advanced online models for successful distance education. Considering the unique challenges of MET, we explore the emerging technologies that could hold the key for future learning in MET post COVID-19. Emerging technologies extends the possibilities for online learning and continues to propel the transformation of distance education [23]. Therefore, technologies such as cloud computing, web-based simulators, VR, artificial intelligence (AI) could play significant role in shaping future MET.

5.3.1 *Cloud computing and web-based simulators*

Foster, Zhao, Raicu, and Lu [11] define cloud computing as "A large scale distributed paradigm driven by economies of scale, in which a pool of abstracted, virtualized, dynamically scalable, managed computing power, storage, platforms and services are delivered on demand to external customers over the internet". In the maritime context, web - based simulator for MET is the software package accessible through online, either cloud based or downloadable, which allows students to interact and practice maritime equipment, tools and systems with specified level of reality [38].

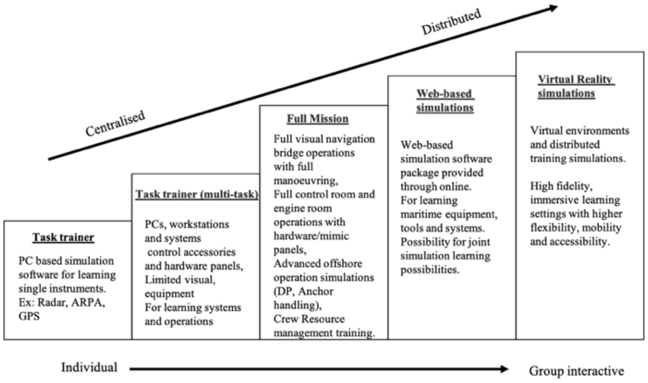

Figure 6. Continuum of simulator development, adapted from Muirhead [31]

Figure 6 illustrates the continuum of simulator development ranging from PC-based part task trainers to full-mission training simulators with increasing sophistication and training capabilities. Muirhead [31] proposed web-based simulation centers as the next step in the continuum where students could access simulator training programs and exercises from home, from ships or training facilities. These web-based simulators have reached the technological feasibility now with cloud computing and faster internet access. However, web-based simulators can work as a remote single task trainer or at best as a multitask trainer but incapable of providing the immersive training capabilities of full mission simulators. Interactive 3D simulations, both desktop PC and VR-based could fill this gap and provide realistic training opportunities remotely. Thus, they are befitting candidate for the next step in the continuum of simulator development.

5.3.2 *Virtual Reality simulations (portable/home VR)*

A recent report on the outlook of Teaching and Learning highlight how emergent technology has the potential to transform future provision of higher education [5]. There are two main envisioned changes for the future education: Extended Reality (XR) and Adaptive Learning (AL). XR covers a wide range of technologies with a real environments at one end of the continuum and immersive virtual environments at the other end. XR includes Virtual reality (VR), Augmented reality (AR) or any computer generated reality [50]. XR provides students with learning experiences that either blends physical and virtual elements (AR) or provides a totally virtual immersive experience (VR). Among the XR technologies, VR is particularly interesting for technology-assisted distance learning for MET. VR has long been considered to have immense benefits for education [8], especially in the field of training with simulators, due to its ability to provide immersive, authentic training experiences [33]. The immersive experience from VR has the intention to replicate a real-life experience. Most commonly, this is achieved through the use of a head-mounted display (HMD) that covers part of the face, have one display each for an eye and simulates stereoscopic depth perception by presenting slightly different views of the virtual world to each eye, and by using sensors to track head and body motion to simulate movements in the virtual environment. With recent advances in VR technology, especially regarding head-mounted displays (HMDs), the interest of using VR HMDs to supplement traditional training simulators has increased [12].

With the introduction of advanced and cost-effective VR HMDs, VR technology promises to offer high quality, immersive simulations at a relatively low cost compared to traditional simulators. The latest generation of VR technologies have lowered the threshold for consumers, offering low latency, high resolution displays, powerful computing and graphical processors available in a compact, portable package with price-points for a VR system at hundreds of dollars, as opposed to several thousand only a few years ago. It is still a significant cost of investment for the majority of households around the world but for professional training contexts the technology has become more accessible than ever before. This makes it now possible for having more realistic and accurate virtual simulation experiences remote to the training campuses [28].

5.3.3 *Adaptive Learning*

Adaptive Learning (AL) is considered as the next stage of computer assisted training as AL systems have the ability to provide students with immediate assistance and resources specific to their learning needs, and relevant feedback [46]. Computer assisted training in general offers benefits for the students to review the delivered topics in the classroom and self-assessment of their own achievement as well as better assessment opportunities for teachers. AL takes this one step further and is based on the idea of adapting the learning methods to the learning styles of the students [24]. It is a data driven technique to provide personalised learning to the students. AL systems dynamically adjust the training content to individual student's knowledge and performance levels, providing it in a fitting order that students require at specific points in time to make progress. It employs artificial intelligence (AI) and learning analytics through algorithms, assessments, student feedback, instructor adjustments/interventions, and various media to deliver the learning contents to students [2]. The utilization of artificial intelligence creates teaching "agents" that adaptively interact with students and offer learning content and feedback through sounds, voice and text. Learning analytics gathers information about the learning outcome of the students and inform the individual and group progress to the students as well as the educators.

In order to be effective, the future MET should not just rely on the developing learning materials and make them available online for students like in traditional e-learning. For an effective training process, knowledge materials should be tailored to various characteristics of the learner, such as specific goals, preferences, knowledge, and learning style, so that appropriate teaching strategies can be used. The goal of the AL is exactly this, and therefore the future MET could benefit considerably by properly applying AL techniques not just in distance learning but also in classroom-based education.

6 CHALLENGES FOR THE TECHNOLOGY-ASSISTED DISTANCE LEARNING IN MET

We have discussed the current response to the pandemic and several potential future scenarios of the use of relatively ubiquitous and emergent technologies for MET applications. At the same time, it is important to consider the challenges of successfully implementing these solutions. As the maritime domain and MET community is highly international with diverse cultures and resources, a one size fits-all approach is rarely appropriate. In particular, differences exist between seafaring nations with regards to resources and technological infrastructure and access, whether at home, in land-based educational facilities or at sea. Access to basic personal computers and a reliable network connection with appropriate bandwidth can be challenging, and thus a potential fundamental barrier for distance learning in its modern form. Just as access to traditional advanced full mission simulators and educational facilities are a barrier for completing one's education and training, lack of access to basic IT infrastructure can create inequalities for opportunities in online educational models from the individual to the MET facility.

6.1 *Techno-Pedagogical skills for students and teachers*

Techno-pedagogical skills are the skills needed for using technology for pedagogical reasons and the competence to integrate technology into teaching. As the education move towards online, it is important to ensure that the teachers and students have the necessary technology skills. The current generation of students (millennials and post-millennials) are increasingly comfortable in adoption of technology and generally confident in using computers, internet and software programs [14]. However, one should not assume that all students have the necessary technology skills for learning and are comfortable using them. It is also likely to have older students other than millennials and post-millennials especially in the continuing education. Thus, it is important to ensure that the students have adequate digital literacy before commencing the technology-assisted distance learning.

Teachers play a key role in the education process by providing reinforcement and expert knowledge to facilitate students, and their specific needs, throughout the learning process. Especially in MET, the direct interaction between the instructor and student within simulator-based training is an important aspect for developing student knowledge, providing feedback through verbal cues and physical gestures [37].

One of the biggest challenges for successful implementation of technology assisted distance learning in MET is faculty adoption of technology. It is yet to be seen how teachers, who were once mostly accustomed to the physical classroom and face to face interaction, are moving forward to adopt new methods of e-teaching and e-learning. Muirhead [31] argue that MET institutions in general have failed to equip the teachers with the didactics training necessary for using new technology in the classroom or laboratory in an effective manner and many students have greater computer skills and knowledge than many of their teachers. This is a key issue and inhibits the more widespread understanding and use of ICT and simulation in the MET learning environment [31]. This is only expected to get worse as the learning environment moves further online and more sophisticated technology such as VR is introduced to MET. The first step to driving adaption of a novel educational tool is to have the faculty involved in the process and continuous collaboration with them. We propose that strong faculty engagement, early on, would motivate educators to stay involved and advocate for the integration of technology assisted distance learning into MET.

7 CONCLUSION

The COVID-19 pandemic has been a major disruption for MET across the world. It is crucial that the maritime educational community learns from its own experiences, share its best practices and also look to other domains for how they handle the crisis to implement practical solutions for uninterrupted education. We have shared our experience with a blended learning approach we adopted for continued education and discussed potential future scenarios for MET. Technology has been utilized and quickly adapted in an attempt to maintain teaching and learning in the short-term, however, longer term solutions and understanding of its impacts must be developed to optimally organize and deploy future MET. The world has been forced to adapt together in the following period like never before in this highly interconnected and globalized society. Thus, we are learning, making mistakes, and adapting together. The future of MET will likely look very different than it did in pre-COVID-19 world. There are important benefits to this change but there are significant challenges that need to be addressed if the future and continuing use of technology in maritime education is to be effective, resilient and have a positive impact on students, educators and the maritime domain as a whole.

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APPENDIX

Questionnaire

	Blended learning course flexibility
Q1	Taking this class in the blended format allowed me to arrange my work for the class more effectively.
Q2	The advantages of taking this class in the blended format outweighed any disadvantages
Q3	Taking this class in the blended format allowed me to spend more time on non-related activities
Q4	There were no serious disadvantages to taking this class in the blended format
Q5	Taking this class in the blended format allowed me to arrange my work schedule more effectively
Q6	Taking this class in the blended format saved me a lot of time commuting to class
Q7	Taking this class in the blended format allowed me to take a class I would otherwise have to miss
Q8	Taking this class in the blended format should allow me to finish my degree more quickly
	Blended learning course quality
Q9	Conducting the course in the blended format improved the quality of the course compared to other courses.
Q10	The quality of the course compared favourably to my other courses
Q11	I feel the quality of the course I took was largely unaffected by conducting it in the blended format.
	Perceived Learner satisfaction
Q12	I am satisfied with my decision to take this course in the blended format
Q13	If I had an opportunity to take another course in the blended format, I would gladly do so
Q14	I feel that this course served my needs well
Q15	I will take as many courses in the blended format as I can
Q16	Conducting the course in the blended format made it more difficult than other courses I have taken
	Technology appropriateness
Q17	The technology used in this course were appropriate for performing the tasks required.