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LIFELONG LEARNING: THE DUTCH PERSPECTIVE ON THE ROLE OF SIMULATORS IN MARITIME EDUCATION AND TRAINING (MET)

Wendie Uitterhoeve[1]*, Gerrit van Leunen[2]

[1] Human Factor Specialist, MARIN, The Netherlands, email: w.uitterhoeve@marin.nl
[2] Maritime Institute Willem Barentsz, NHL Stenden University of Applied Science, The Netherlands

***Corresponding author: Marin, PO Box 28, 6700 AA, Wageningen, The Netherlands

Abstract: Over the past 25 years, the role of simulators has increased dramatically within Dutch Maritime Education and Training (MET) in parallel with new educational insights like competency-based learning. Research demonstrated that the learning efficiency for certain competences is higher in the simulator instead of that made during sea time. Relevant trends and developments that will affect MET in the future relate to maritime innovations, safety, simulator developments, human factors and didactic insights. Both sea time and simulator training contribute to the development of competencies, each having specific benefits and drawbacks. Within a balanced training program the optimal combination of on board experience, and simulator practice with online and offline learning, leads to an effective development of competences.

Keywords: Maritime Education and Training (MET), simulators, lifelong learning, competency based learning.

1. INTRODUCTION

The Dutch Maritime Strategy 2015–2025 values the high quality of its maritime education system, as it is an important pillar for safe and efficient maritime business. To that effect, the Dutch government stimulates a high level of interaction and cooperation between both the maritime education institutes and the maritime sector. Aligning these needs is necessary as the technical innovations renew in rapid succession. Education, professional learning, and training are essential to retaining professionals in the maritime sector.

Schools want to be able to quickly adapt to those changes and innovations. In this innovative maritime environment, continuous education and training are also necessary to remain attractive for those working in it and maintain their employment in the sector. As technologies change, so do the skill sets needed to operate them.

Within the Dutch educational system, the role of simulators has increased dramatically over the past 25 years, in parallel with changes in teaching methods based on new educational insights like competency-based learning. This raises the question of how to optimize the combination of different learning solutions at school, onboard, and in the simulator.

This article provides an overview of the relevant trends and developments that will affect the maritime educational system in the future. They are primarily based on research, which MARIN (Maritime Research Institute Netherlands), based in Wageningen (NL) and Houston (USA) has completed for the Dutch Ministry of Infrastructure and Water Management. In close cooperation with the Maritime Simulator Training Center (MSTC) and the Maritime Institute Willem Barentsz (MIWB), two parallel research projects have been conducted for this ministry: the employment of simulators in Dutch maritime education and training and the related topic of using simulator time to reduce sea-time by utilizing the benefits of incorporating simulator training alongside onboard training. These studies aimed at initiating further research, development and implementation to improve Dutch MET.

2. SEA TIME REDUCTIONS

In the 1990s, MSTC (situated on the Dutch Wadden Island of Terschelling) operated the first common (civilian) simulator centre for all Dutch maritime officer courses. Over time, it has researched the effectiveness of its simulator training using the experience of over 20 000 students trained in the simulators. The learning efficiency for developing the skills as studied appears to be higher in the simulator instead of making sea time [MSI TNO 1996; Hiemstra et al. 2012].

This has resulted in an agreed practice to use simulator time for the reduction of sea time for maritime cadets for over 25 years. The Dutch model allows for a maximum of a 60-day reduction in sea time for 15 days of simulator training. This reduction creates flexibility to fit the sea time periods within the educational periods.

Also in the United Kingdom, the topic of simulator use has been discussed extensively for instance by the Merchant Navy Training Board (MNTB) which has, in 2020, put together a working group to develop proposals for British cadet training that includes simulator time whilst aiming to develop a UK simulator training model.

3. MARITIME EDUCATION AND TRAINING IN THE NETHERLANDS

Maritime education in the Netherlands is based on vocational courses at the post-secondary or bachelor's degree level. All courses meet both the national education standards as well as those of the STCW (IMO Standards of Training, Certification, and Watchkeeping). According to internationally agreed standards, 360 days of sea

time is compulsory to obtain a Certificate of Competency (CoC). In addition to successfully completing theory and practical courses, Dutch students have to complete 300 days within two five-month practical internship periods on board. The remaining 60 days are replaced by the 15 days of simulator training. All Dutch nautical colleges have their own merchant simulators in which they bring theory into practice in a safe and controlled environment. Within the Royal Netherlands Naval Institute's curriculum simulator training is an integral part of the course exam. Together with spending time at sea (sea time), which is a substantial part of the Royal Netherlands Navy (RNLN) courses, the simulator proof is the final exam. Secondary education for inland shipping in The Netherlands consists of a vocational course during which full-time education is combined with internships and simulator training or a more practical focused training-on-the-job course during which work is supplemented with periods at school.

Obtaining the Certificate of Competency is the beginning of lifelong learning. More and more companies are training specific skills in-house with their own simulators, such as dredging or dynamic positioning. These are in-company training programs in which the connection between simulation and practice is strong. Simulator training is a mandatory part of a next career move at Nederlands Loodswezen (Dutch Pilotage Service). Carnival Corporation with its own training centre Csmart in Almere (NL) maintains a common standard throughout its fleet: one culture with uniform working methods, safety standards, and an integrated promotion and assessment system for the entire organization.

Simulators also provide the opportunity to prepare and practice the execution of new operations before the real work begins. As a knowledge institute, MARIN has a lot of experience in simulator R&D, experiments, and preparing/rehearsing specific and complex maritime operations. With this experience, MARIN forms an important link between the development of knowledge and the sharing and application of that knowledge with the maritime sector. Tailor-made training courses for maritime professionals, whether or not preceded by a design workshop in which the best operational strategies are being examined, are an example of this.

4. TRENDS

During the research into the use of simulators for maritime education and training in the Netherlands, we made an overview of trends in the maritime sector and (maritime) education and training.

4.1. Maritime innovations

Ships are becoming cleaner, smarter and safer. On-board systems have been updated for years and are now reaching their end of life (performance limits). This requires innovative solutions and different design concepts. These include cleaner ships that are partly propelled by wind or have zero-emission engine rooms. Or smart ships with information and communication systems onboard and ashore, as part of a logistics chain, that exchange information autonomously. Decision support systems are introduced to increase situational awareness. Technical and social innovations change the composition of the crew on board. Adaptation to new developments within a growing internationalizing environment comes with its cultural challenges. Crew reductions continue as tasks change or move ashore. As a result, there may be less opportunity to learn onboard. At the same time, new jobs are being created ashore for which there are currently no on-the-job training positions.

Humans will continue to play an important role in future operations both ashore and onboard. You can't learn everything on board, but you can learn most of it in the simulator.

Fig. 1. Autonomous shipping as example of maritime innovations

4.2. Safety

Safer ships work with a different safety culture where active risk management and learning from near misses and accidents are more central than finding the culprit. Proactive risk management, as it is now on the maritime safety agenda, goes one step further by estimating and controlling risks in advance. Safety starts with behaviour and awareness of the impact of our own behaviour on the safety of our ship.

A simulator lends itself naturally to training those safety procedures. What can one do in extreme conditions and how does one do this safely?

Royal Dutch Shell's well-known Hearts and Minds program is the first example of the introduction of a company-wide safety awareness program [Van de Graaf 2007]. Later, others such as Carnival Corporation and Big Lift Shipping followed suit with similar programs.

4.3. Simulator developments

Today we can realistically simulate complex operations. The behaviour of the ships, the outside image, and the instruments in the simulators have been greatly improved so that the interaction between people, technology, and the environment is markedly improved. It is precisely this interaction that makes the simulator experience so realistic. While we used to use simulators mainly to develop individual (technical) skills, nowadays we can also train team performance and non-technical skills. Nowadays we can link different simulators – in the European Maritime Simulator Network EMSN – in a scenario.

Then we can, for example, pay attention to cultural differences related to assertiveness and leadership, which is an integral part of Bridge Resource Management (BRM). We also see simulators being placed on board, and both augmented (AR) and virtual reality (VR) are being introduced. E-learning also creates time-independent learning opportunities. With 'serious gaming' it is possible to explore various perspectives around a theme or to introduce new procedures to a team.

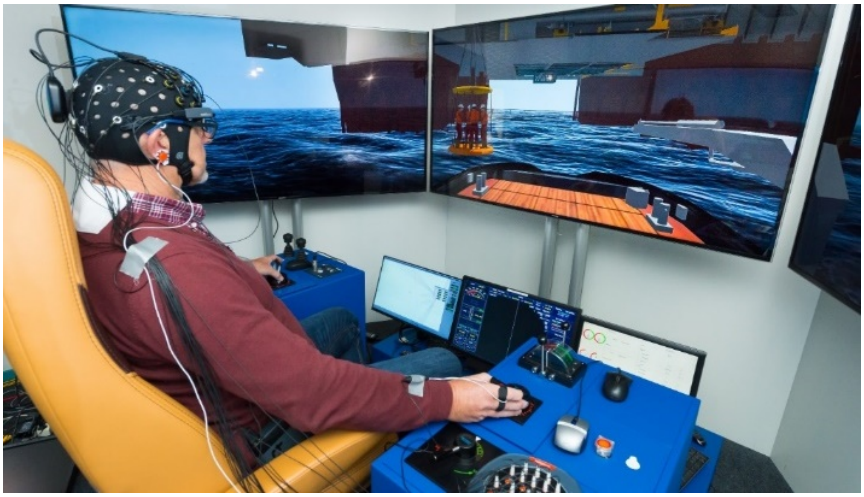

Fig. 2. Measuring human performance in a simulator

4.4. The human factor

Since non-technical skills have been incorporated into STCW's Manila amendments in 2010, the 'maritime human factor' is getting more attention. Also, or perhaps especially, in autonomous shipping and shore control centres. Skills required for good bridge resource management such as leadership and management, collaboration, situational awareness, and decision making are now an integral part of the training. The trick is to integrate those non-technical skills into the technical task performance and not to see them as two separate areas for development. The simulator environment lends itself well to this because you can create situations that are not possible or are unsafe in practice. Additionally, measuring human performance is getting better and better. Physiological feedback on workload, collected with for example heart rate measurements, combined with insight in information collection strategies made visible with eye trakers add objective context to the performance.

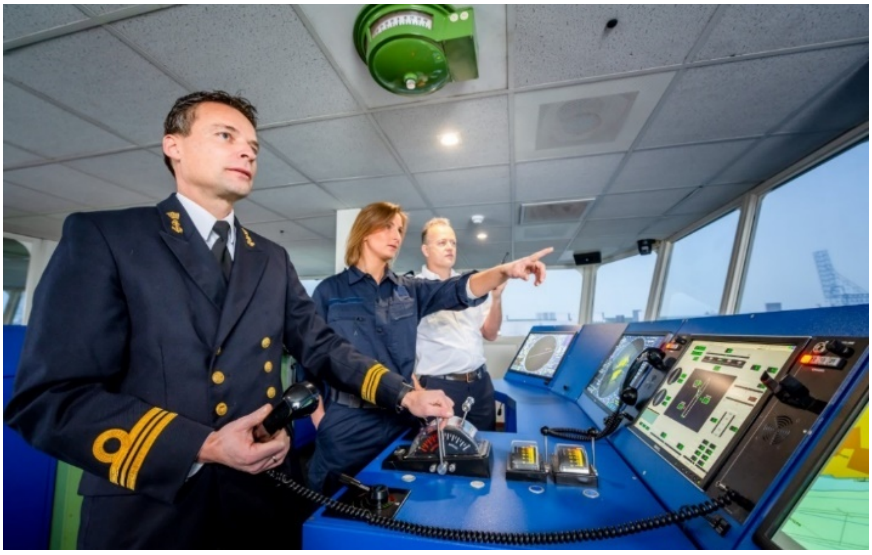

Fig. 3. Practice non-technical skills for leadership in a simulator

4.5. New didactic insights

In the past, the general motto was: 'knowledge is power'. In this day and age, however, knowledge is accessible to everyone. Today's society puts more value on being able to combine knowledge into new applications. The development of advanced cognitive skills such as understanding, solution-oriented action, analytical

thinking, seeing coherence, and reflecting on processes (21st-century skills) are seen as much more relevant. Adaptability, leadership, and communication are non-technical skills that are going to make a difference. This requires new teaching methods that develop these skills and attitudes in addition to acquiring knowledge. The younger generation will grow up with these automatically, while for the older generation this is new and an element to actively pursue during their lifelong learning. Competency-based education is a suitable answer to this. Not just for the younger generation, but also for adult education, competency-based training is the best way to link up with their already developed professional knowledge, skills, and abilities.

New educational concepts such as High Impact Learning [Dochy et al. 2015] have been introduced. This revolves around hybrid education with a good mix between online and offline learning, between formal and informal learning.

In the maritime sector, this takes shape in the combination of classroom instruction, projects, simulator training, and internships. Education in which passing tests and scoring on STCW criteria are not an end in itself, but in which it is about preparing for the onboard tasks. Education in which the trainer/teacher coaches the student or professional on the learning process instead of the content.

New competencies combined with more objective behavioural measurements form the basis for the identification and development of future performance criteria applicable for both coachings on board and in a simulator environment. Implementation of new assessment standards requires a proven validation of these performance criteria.

4.6. Inspiration from other fields of expertise

We also looked at the use of simulators used in other disciplines. Within the aviation industry, it is mandatory to perform a proficiency check twice per annum. The pilot's license remains only valid after an exam has been taken in a simulator. The interaction between train drivers and their service manager (traffic control) and the introduction of new safety systems such as ERTMS are trained by using simulators. (ERTMS: European Rail Traffic Management System, is the system of standards for management and interoperation of signaling for railways by the European Union).

Dutch safety regions train the cooperation between different units in large-scale incidents with role-plays, serious games, and simulations. Based on the first driving lessons in a car simulator, it is possible to determine someone's driving behaviour. During the COVID-19 lockdown period(s), driving simulators turned out to be an invaluable alternative for driving lessons. Finally, in the medical world, simulators are an integral part of training and replace practicing on real patients.

5. SIMULATORS USE IN A BALANCED TRAINING PROGRAM

Simulators have – partly thanks to the increased level of reality – acquired a prominent role in education and professional training. The simulator is (and remains) an integral part of lifelong learning which starts at school with a balanced package of online and offline learning, simulations, and practical internships. However, increasing that reality is not the only thing. The use of good pedagogical tools becomes more important in competence-based learning and is absolutely necessary for increasing the efficiency of simulator training [Sellberg 2017]. Competencies are composed of skill, knowledge, and attitude.

You can divide ways in which the competencies can be learned and acquired into three categories:

1. Competencies that can only be learned on board.
2. Competencies that can be learned board as well as in a simulator.
3. Competencies, which can only (or much better) be learned in a simulator.

With this in mind, it is good to realize that both the simulator and the internship experience onboard have their individual strengths, depending on the learning objective. In the simulator, you can make mistakes without serious consequences. Above all, you can (quickly) apply newly learned knowledge in an environment. Onboard you will experience completely different elements of the job environment and the maritime business: long periods away from home, watchkeeping, monotonous operations, alertness, a multicultural team, and the convergence of all elements from the training in an operation. See the table below for more details.

To increase the transfer of learning, it is important to identify similarities and differences between the simulator and practice during the training. Limitations in the simulator do not have to be limitations on board, and vice versa.

When professionals return during refresher courses to the basics (the theory) and reflect on the company-specific implementation in practice, this increases awareness of the gap between work as it was conceived and work as it is performed.

If you experience the difference between ‘work as done’ and ‘work as imagined’ in the simulator, you can change behaviour. On the one hand, it can make you aware that taking those tight turns can be tricky. On the other hand, it can make it clear to you that the company's procedures are not applicable (anymore) in the real world. How great would it be if you could execute this with students and maritime professionals in a simulator? Would that contribute to an even better connection between maritime education and professional development?

Table 1. Benefits and cons of a simulator and onboard learning

Benefits of simulator training	Benefits of on-board learning
• Possibility to make mistakes without damage consequences • Training of irregularly occurring situations plus dangerous situations • The simulator guarantees controlled conditions and repeatability • Learning content is given in a structured way • Learning content matches individual capabilities • The organisation of the learning process is more efficient • Coaching and performance monitoring by professional trainers • Assessment by professional simulator instructor using agreed/validated criteria • Possibility to train team performance • Possibility to train on a large variety of vessel types • The trainee has a more active role and can exercise situations that would normally be dealt with by more senior officers	• Experience the real-life on board: o A long period away from home o International crew, different cultures o Social structures are forced by a limited environment. • Exposure to routine and day-to-day situations • Experience all the additional tasks of the job of a watch officer • Experience the effects of stress, fatigue, and boredom during watch schedules • Experience the effects of working conditions: e.g. motion, noise, and temperature • Experience the true delays involved with working on a large ship • Maintain and repair machinery
	Cons of onboard learning
	• Difficult situations are dealt with by more senior personnel • Dangerous situations are avoided • No validated performance criteria • Assessments are dependent on the individual mentor • On-board, the level and amount of learning content can be too high or too low

6. QUESTIONS LOOKING AT THE FUTURE

With so many innovations happening in the maritime sector, the simulator technology and in the educational system we ask ourselves a few questions:

- Is the current agreed hybrid practice, with a combination of simulator training and onboard learning, still valid after 25 years, or does it need an update? Do new teaching methods and the need to develop other competencies make the effectiveness of simulators even better?
- How can we achieve more synergy in a simulator environment between maritime professionals who train complex skills and operations and students who are mainly developing their basic skills?
- Which innovations really do contribute to the development of a lifelong continuous learning path and maintaining the high quality of maritime education in the Netherlands?

- How can the utilisation of simulators and their effect on learning be increased for the maritime sector by learning from other sectors such as aviation?

7. ACKNOWLEDGEMENTS

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