JOURNAL OF MARITIME RESEARCH

Vol XXII. No. I (2025) pp 262–268

ISSN: 1697-4840, www.jmr.unican.es

Satisfaction survey for the evaluation of training in a modern bridge simulator

Panagiota Lalou[1,*], Vasilios Tsoukalas[2], Georgios Sarantopoulos[1], Dimitrios Arsenopoulos[1]

ARTICLE INFO

Article history:
Received 30 Jul 2024;
in revised from 05 Aug 2024;
accepted 16 Aug 2024.

Keywords:
Marine education, Bridge officers, Bridge room simulator, Simulator training evaluation.

ABSTRACT

The purpose of this research is to evaluate a modern bridge simulator from a trainees' point of view and investigate whether a trainee can acquire the necessary skills and abilities for his/her role on board. In addition, to determine whether training in such a simulator can replace practical onboard training. The research was performed in the spring semester of the academic year 2022-2023 in the Merchant Marine Academy of Athens. A questionnaire was distributed and answered by 293 students of the School of Bridge Officers. Respondents were divided into groups, based on academic semester of study, previous simulator use, and shipboard training experience. The results showed that the students are completely satisfied with the quality of the hardware and software of a modern bridge simulator, while previous simulation experience also contributes to this. They also seem satisfied with the training experience in the simulator, as its fidelity and pedagogical environment offered, helps them absorb knowledge from classroom training, practice in navigation scenarios and acquire the technical and non-technical skills required for their training as merchant marine officers. However, they feel that simulator training cannot replace onboard training.

1. Introduction.

Maritime education and training (MET) mainly consists of three parts, namely, theoretical or laboratory education and training, offered in maritime academies, simulation training, which uses bridge or engine room simulators to recreate realistic scenarios and environments, and shipboard training, in which trainees learn and acquire skills while performing actual tasks and duties on a vessel (De Oliveira et al. 2022, Renganayagalu et al. 2019). Simulator technologies, used in simulator training, support instructors to continuously monitor, assess, and provide feedback to the trainees during training sessions (Sellberget. Al. 2018). Similarly, a trainee needs to have the complete feeling of being onboard a real vessel with the use of all instruments and systems required for its navigation and operation of a ship (Bhaskaran 2018).

Modern simulators have upgraded their role in marine education and training, offering many important benefits and having overcome many disadvantages of the simulators of the previous decade. They provide a modern and realistic training environment that closely resembles real maritime operations. They simulate ship's bridge, engine room, cargo handling areas and other critical areas of the ship. Trainees can practice various scenarios, maneuvers and dangerous situations in a safe and controlled environment, gaining hands-on experience without the risks associated with real operations. Furthermore,

[1]Professor, Dept. of Marine Engineering, Merchant Marine Academy of Athens, Paralia Aspropyrgou, 19300 Aspropyrgos, Greece, e-mail: glalou@hotmail.com; https://orcid.org/0000-0003-2742-2804.

[2]Professor, Dept. of Marine Engineering, Merchant Marine Academy of Athens, Paralia Aspropyrgou, 19300 Aspropyrgos, Greece, e-mail: vdtsoukalas@yahoo.com; https://orcid.org/0009-0001-8896-5047.

[3]Dept. of Master Marine, Applications Professor, Phd cand, Ports Management and Shipping Dept, National and Kapodistrian University of Athens, Greece, e-mail: gnsarantopoulos@gmail.com; https://orcid.org/0009-0004-1890-8348.

[4]Dept. of Master Marine, Assistant Professor, Merchant Marine Academy of Aspropyrgos, Greece, e-mail: dm.arsen1968@gmail.com; https://orcid.org/0009-0003-7424-9773.

[*]Corresponding author: Panagiota Lalou. E-mail Address: glalou@hotmail.com.

simulators allow the reproduction of a wide range of scenarios that may be difficult or rare in real situations. Trainees can face adverse weather conditions, heavy traffic, emergencies and complex navigational conditions (Sharma et al. 2019, Zgyeret al.2019).The use of simulators in modern MET practices is regulated by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978, as amended, which under certain circumstances can replace on-board training (STCW 2011).

This training prepares students to handle such situations effectively, improving their confidence and ability to make critical decisions under pressure. In addition, simulators facilitate the objective assessment of trainees' performance. Instructors can assess trainees' skills, decision-making abilities, situational awareness and adherence to protocols in a standardized manner. Performance metrics and feedback from simulations help identify strengths and areas for improvement, enabling targeted training interventions and ensuring skills acquisition. Moreover, simulator training offers a cost-effective alternative to on-board training. Conducting training on actual vessels can be expensive, requiring fuel, maintenance and crew resources. Simulators provide a more affordable option, reducing operating costs while providing high quality training. They also enable efficient use of training time, allowing trainees to practice specific skills repeatedly and focus on areas that require improvement.Thus, the use of simulators has become an essential element in the training of officer candidates, increasing the hours of training as well as the training subjects taught in the simulator. This means that alongside classroom training, the use of simulators, as a tool to familiarize students with the marine environment and improve their skills, is also increasing. On the other hand, sea training on-board a ship is essential for all seafarers and plays an important role in the education and training of candidate officers. However, the on-board training opportunities offered by shipping companies have declined significantly in recent years, with minimum manning levels combined with an ever-increasing level of automation, creating fewer opportunities for officer training (Albayrak et al. 2010).

The increased use of marine simulators in the education and training of seafarers requires ensuring that training using these simulators is effective and meets the needs of the trainees as well as the expectancies of the maritime industry. Due to their great importance in the training of seafarers, in the last decade several researchers have evaluated their use or proposed ways of better utilizing them in maritime education (Tsoukalas et al. 2015, Kandemir et al. 2018, Kim et al. 2021). In this direction, it has also been investigated the trainee's perception of self-efficacy and skill development following participation in simulation exercises in simulators with different levels of fidelity (Renganayagalu et al. 2019).

Simulation or on-board training has as key-outcome the transfer of skills from training environment to the real-job environment. The Standards for Training, Certification and Management (STCW) approve the use of simulator training that complies with Section A-1/12 as a substitute for on-board training (STCW-2011). Moreover, amended STCW Convention, is greatly focused on technical proficiency and the so-called non-technical skills acquisition. The technical skills relate to handling the equipment of the ship. In addition to the technical skill development requirements, there is the need to develop and evaluate the non-technical skills of bridge officer candidates. The term non-technical skills include the cognitive, social and personal skills that contribute to the efficient and safe performance of navigational tasks (Flin et al., 2008, Sellberg 2018). Among them, more emphasis has been placed on skills, such as communication, leadership, situational awareness, decision-making and teamwork (Conceição et al., 2017).

Simulators are designed to replicate the real working environment, and it is widespread assumed that the effectiveness of the replication is mainly owing to the fidelity or realism of simulator. Fidelity is generally defined as the simulator's ability to replicate the real environment as closely as possible (Hays 1980, Kim et al. 2021). Simulators have been categorized into low, medium and high fidelity simulators (Veritas, 2011). However, regarding the effect of simulator fidelity on learning, in recent years there has been much controversy among researchers as to whether high fidelity is superior to low fidelity in terms of learning outcomes. The relationship between learning outcome and fidelity has been shown to be non-linear and it has been recognized that increasing fidelity does not necessarily improve learning outcomes (Renganayagalu et al. 2019, Massoth et al. 2019, Sellberg 2017, Hamstra et al. 2014)).

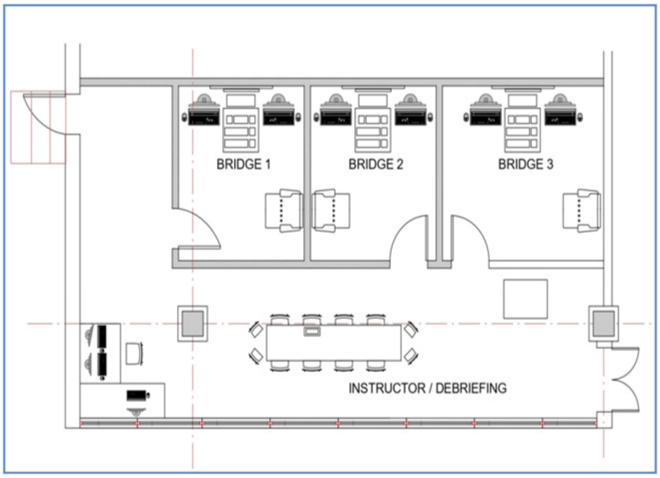
The objective of this paper is to evaluate training on a modern bridge simulator considering trainees' satisfaction with simulator's hardware and software quality. Moreover, to evaluate the simulation training experience, taking into account parameters such as simulation flexibility and fidelity or the pedagogical effectiveness of the simulator and investigating whether trainees can learn in a simulation environment, activities they are expected to undertake on board, acquiring the necessary technical and non-technical skills. Furthermore, to investigate whether and to what extent training in such a simulator can replace practical on-board training. For this purpose, a questionnaire was drawn up and distributed to the students of the 2nd, 3rd and 5th semesters of the Bridge Officers Department of the Athens Merchant Marine Academy.

2. Experimental Setup - BRS in Merchant Marine Academy of Athens.

The Navi-Sailor NTPRO 5000 ship bridge handling simulation system of the Deck Officers' department at Merchant Marine Academy of Aspropyrgos, includes three bridges (Figure 1), each of which represents an "own ship", as well as one instructor station. The configuration, positioning and equipment of the bridges has been done in such a way, as to give complete realism, representing a real bridge with sufficient space, for the training of at least five people simultaneously: Team leader – Master, ECDIS operator, RADAR-ARPA operator, Helmsman, Communication and GPS indicator on the chart table.

The simulation system includes two hundred own ships of different types and loading conditions. The simulator involves many types of own ships, for example, passenger ships, cruise

Figure 1: Navi-Sailor NTPRO 5000 bridge simulator installation.



Source: Authors.

ships, bulk carriers, tankers and container ships. Each ship consists of:

- Maneuvering control console
- Radar ARPA & ECDIS
- Communication workstation
- Chart table
- Steering wheel equipment
- Instrument panel

The equipment, consoles and workstations are installed and arranged just like on a real ship. Specific emphasis has been given on the instruments and control panels of the bridge, which are similar in appearance, function, as well as capabilities, to those of real ships. All systems related to the integrated bridge system include failure control instruments and methods of training and evaluating the trainee in the use of advanced equipment and technology. They enhance the familiarization and training to comprehend the limitations of automatic systems.

The simulator also comprises forty-one models of tugs of various types and power that will enable the realistic simulation of tug assistance, during maneuvers and escort operations by any method. It simulates pulling, pushing, towing position change and escorting. The simulator also involves practice areas with correct data for land, depth, buoys, tidal currents and visuals that will be appropriate to nautical charts and publications on ECDIS used for relevant training purposes. In addition, one hundred practice areas are provided around the world and selected for various types of navigation.

3. Research Methodology.

For the purposes of this research, a questionnaire was used, which was shared and answered by students trained in the simulator as part of an academy course. The questionnaire was answered by 293 students of Merchant Marine Academy of Athens, in June 2023, almost at the end of the academic semester, in which they used the simulator. Respondents were divided into groups based on academic semester of study, previous simulator use, and onboard training. The questionnaire was written in English and then translated into Greek. The questionnaire (Appendix 1) consisted of three parts:

A. Simulator hardware and software satisfaction index (A1: Hardware quality satisfaction index, A2: Software quality satisfaction index) (7 questions)

B. Simulator experience satisfaction index (8 questions)

C. Simulator training satisfaction index compared to on board training (3 questions)

The third part of the questionnaire was answered only by students who have already taken an educational trip, i.e. mainly by those who are in their 3rd and 5th academic semesters.

Regarding the independent variables the research hypotheses in this research have been selected as follows (Figure 2):

H0.1a: Simulator hardware and software satisfaction is not affected by previous simulation experience.

H1.1a: Simulator hardware and software satisfaction is affected by previous simulation experience.

H0.1b: Simulation experience satisfaction is not affected by previous simulation experience.

H1.1b: Simulation experience satisfaction is affected by previous simulation experience.

H0.1c: Simulator training satisfaction compared to onboard training is not affected by previous simulation experience.

H1.1c: Simulator training satisfaction compared to onboard training is affected by previous simulation experience.

H0.2a: Simulator hardware and software satisfaction is not affected by academic semester.

H1.2a: Simulator hardware and software satisfaction is affected by academic semester.

H0.2b: Simulation experience satisfaction is not affected by academic semester.

H1.2b: Simulation experience satisfaction is affected by academic semester.

H0.2c: Simulator training satisfaction compared to onboard training is not affected by academic semester.

H1.2c: Simulator training satisfaction compared to onboard training is affected by academic semester.

H0.3a: Simulator hardware and software satisfaction is not affected by onboard training.

H1.3a: Simulator hardware and software satisfaction is affected by onboard training.

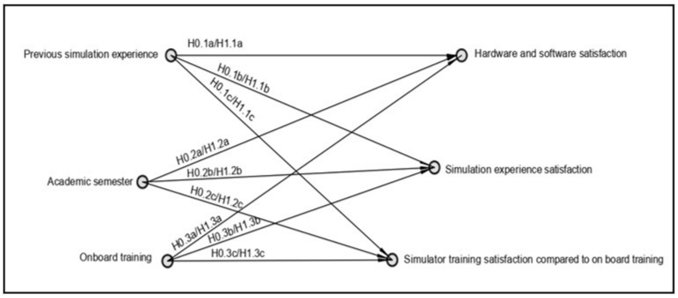
H0.3b: Simulation experience satisfaction is not affected by onboard training.

H1.3b: Simulation experience satisfaction is affected by onboard training.

H0.3c: Simulator training satisfaction compared to onboard training is not affected by onboard training.

H1.3c: Simulator training satisfaction compared to onboard training is affected by onboard training.

Figure 2: Research hypotheses diagram.



Source: Authors.

In order to examine the above hypotheses, Mann-Whitney – U test or Kruskal – Wallis test were applied, depending on the independent variable. All analyses were calculated with IBM SPSS Statistics.

4. Data Analysis.

The questionnaire was answered by 293 students of Merchant Marine Academy of Athens. After collecting the questionnaires and processing the research data, Table 1 shows the frequencies of occurrence regarding the independent variables selected: It was used the Likert scale, a type of psychometric response scale widely used in these questionnaires. Each question had five response options; "very dissatisfied" (score 1), "not satisfied" (score 2), "neutral" (score 3), "satisfied" (score 4), "very satisfied" (score 5).

Table 1: Participants' distribution.

Gender	Male: 234 (79,9%) Female: 59 (20,1%)
Academic semester	2^{nd} : 121 (41,3%) 3^{rd} : 94 (32,1%) 5^{th} : 78 (26,6%)
Have you done educational trip?	Yes: 172 (58,7%) No: 121 (41,3%)
Have you ever used any kind of simulator before?	Yes: 214 (73%) No: 79 (27%)

Source: Authors.

For the statistical analysis, the following continuous variables were created, which express the average score of the responses of each part of the questionnaire:

a) Hardware quality satisfaction index:

$$HI=\frac{\sum(scores\ of\ questions\ A1-A2-A3)}{3}$$

b) Software quality satisfaction index:

$$SI=\frac{\sum(scores\ of\ questions\ A4-A5-A6-A7)}{4}$$

c) Hardware and Software quality satisfaction index:

$$HSI=\frac{\sum(scores\ of\ questions\ of\ part\ I)}{7}$$

d) Simulation experience satisfaction index:

$$EI=\frac{\sum(scores\ of\ questions\ of\ part\ II)}{8}$$

e) Simulation training satisfaction index:

$$TI=\frac{\sum(scores\ of\ questions\ of\ part\ III)}{3}$$

Table 2 shows mean and standard deviation of each index. It is observed that students satisfaction degree by the hardware and software of the simulator (*HSI*) and students' simulator experience (*EI*) *is* quite high (means 3,73 and 3,70 respectively), but the satisfaction degree drops significantly when compared to on board training (mean = 2,21).

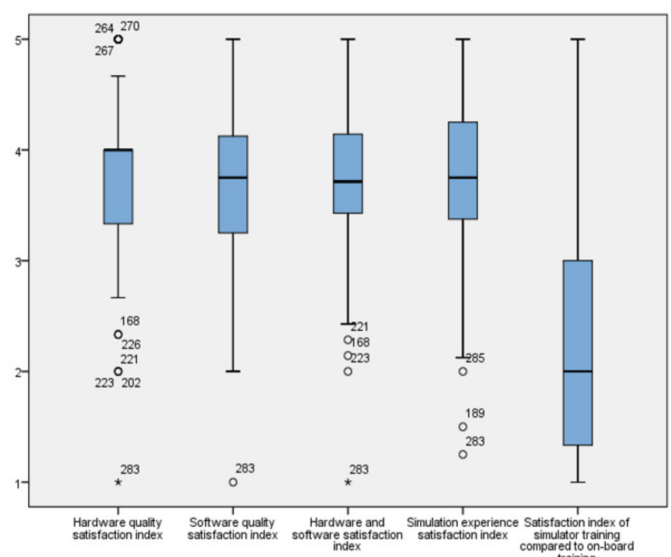
Table 2: Mean of scores and standard deviation.

Index	Score
Hardware quality satisfaction index (*HI*)	3,78 (0,76)
Software quality satisfaction index (*SI*)	3,68 (0,71)
Hardware and software satisfaction index (*HSI*)	3.73 (0,68)
Simulation experience satisfaction index (*EI*)	3,70 (0,70)
Satisfaction index of simulator training compared to on-board training (*TI*)	2,21 (0,96)

Source: Authors.

We reach the same conclusion by observing boxplots of the satisfaction indexes (Figure 3).

Figure 3: Boxplots of satisfaction indexes.



Source: Authors.

Table 3 shows the mean value and standard deviation of the score of each question of part II and III. It is concluded that the average value of the score of each question of the 2^{nd} part which concerns 'Experience Satisfaction Index', ranges from 3,47 to 3,84, which shows that students are quite satisfied with the experience of using the simulator. In contrast, the mean scores on questions of 3^{rd} part, which concerns 'Simulation experience training compared to on-board training', are significantly lower. This part of questionnaire was answered only by students who have already taken an educational trip. Especially the question ”The simulator training can replace on-board training” had the lowest mean score (1,81), and by far, lower than rest of the questions.

Table 3: Average score and standard deviation of each question of Part II and III.

Question regarding "Simulation Experience Satisfaction Index"		Mean (Std Deviation)
1	The simulator trains you, in a safe environment, in scenarios of dangerous situations that lead to accidents	3,61 (1,056)
2	The simulator allows you to learn from correcting your mistakes and train yourself to use alternative scenarios	3,72 (0,992)
3	The simulator facilitates the acquisition of skills through a better understanding of the training content and the consequences of wrong actions	3,77 (0,888)
4	The system is flexible. Facilitates changes between different scenarios (from low speed to high speed or from narrow channel to open sea navigation)	3,63 (0,877)
5	The simulator is pedagogical effective	3,82 (0,909)
6	Simulator fidelity	3,47 (0,851)
7a	The simulator helps you assimilate and apply technical knowledge and skills	3,84 (0,807)
7b	The simulator helps you assimilate and apply non-technical knowledge and skills	3,63 (0,943)
Question regarding "Simulation Training Satisfaction Index Compared to On board Training		
1	Overall satisfaction with simulation training	2,17 (1,211)
2	Simulator training provides knowledge and skills equivalent to on-board training	2,9 (1,061)
3	Could simulator training replace onboard training	1,81 (1,134)

Source: Authors.

The results show that students are satisfied with their training in a modern bridge simulator, whether it concerns the use of technological equipment and software or the educational evaluation of learning through the simulator and this concerns all related questions. In contrast, the picture changes when simulator use is compared to on-board training. From their answers to these questions, it can be concluded that there is a clear preference of the students for practical training at sea, which moreover seems irreplaceable.

5. Hypothesis Testing.

It was investigated whether there is a significant difference in the mean score of each of the three indices: Hardware and Software Satisfaction Index (HSI), Simulation Experience Satisfaction Index (EI) and Simulator Training Satisfaction Index compared to on-board training (TI) between groups of independent variables: a) Previous simulator use, b) Academic semester and c) Onboard training. The significance level was set at 0,05. Data were tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The results (Table 4) show that none of the three variables continue to be normally distributed (p-value < 0,05), and therefore non-parametric tests were used.

Table 4: Results of normality tests.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Hardware and software satisfaction index	,080	171	,009	,972	171	,002
Simulation experience satisfaction index	,082	171	,007	,969	171	,001
Satisfaction index of simulator training compared to on-board training	,190	171	,000	,898	171	,000

a. LillieforsSignificanceCorrection

Source: Authors.

To examine whether there is a difference in student satisfaction between those who have used any type of simulator in the past and those who have not, the Mann-Whitney test was used. The results show that there is a significant difference in the ”Hardware and Software Satisfaction Index” (HSI) between the two groups (p-value = 0,017 < 0,05). As it is shown in Table 5, the degree of satisfaction of students who have not used any kind of simulator in the past is lower than those who have used it. No differences were observed between groups for ‘Simulation Experience Satisfaction Index’ (EI) (p-value = 0,848) and ‘Simulator Training Satisfaction Index compared to Onboard Training’ (TI) (p-value = 0,346).

Table 5: Results of mean value and standard deviation of satisfaction indexes by previous simulator use.

Index	Previous Simulator Use	
	Yes	No
Hardware quality satisfaction index	3,75 (0,77)	3,88 (0,72)
Software quality satisfaction index	3,64 (0,70)	3,82 (0,72)
Hardware and software satisfaction index	3,68 (0,68)	3,85 (0,66)
Simulation experience satisfaction index	3,70 (0,67)	3,69 (0,78)
Satisfaction index of simulator training compared to on-board training	2,20 (0,95)	2,31 (0,98)

Source: Authors.

To examine whether there is a difference in the degree of student satisfaction depending on the academic semester of the student, the Kruskal – Wallis Test was used. The results show that there is a significant difference in ‘Simulation Experience Satisfaction Index’ (p-value = 0,047 < 0,05). Table 6 shows that the mean score of the simulation experience satisfaction index is lower for students in the 2nd semester than those in the 3rd and 5th. No differences were observed between groups for the ’Hardware and Software Satisfaction Index’ (HSI) (p-value = 0,415) and ’Simulator Training Satisfaction Index compared to on-board training’ (TI) (p-value = 0,102).

Table 6: Results of mean value and standard deviation of satisfaction indexes by academic semester.

Index	Academic Semester		
	2nd	3rd	5th
Hardware quality satisfaction index	3,69 (0,78)	3,94 (0,68)	3,73 (0,79)
Software quality satisfaction index	3,72 (0,70)	3,71 (0,71)	3,59 (0,73)
Hardware and software satisfaction index	3,72 (0,68)	3,81 (0,64)	3,65 (0,71)
Simulation experience satisfaction index	3,57 (0,71)	3,77 (0,65)	3,79 (0,72)
Satisfaction index of simulator training compared to on-board training	-	2,26 (0,95)	2,11 (0,94)

Source: Authors.

To examine whether there is a difference in the degree of student satisfaction between those who have taken an educational trip, the Mann–Whitney test was used. The results (Table 7) show that there is a significant difference in the ”Simulation Experience Satisfaction Index” between students who already have shipboard training experience and those who do not (p-value = 0,011). This indicates that students who have received onboard training are more satisfied with simulator training than those who have not. No differences were observed for the 'Hardware and Software Satisfaction Index' (p-value = 0,875).

Table 7: Results of mean value and standard deviation of satisfaction indexes by onboard training.

Index	On board training	
	Yes	No
Hardware quality satisfaction index	3,85 (0,73)	3,69 (0,78)
Software quality satisfaction index	3,66 (0,72)	3,72 (0,70)
Hardware and software satisfaction index	3,74 (0,68)	3,71 (0,68)
Simulation experience satisfaction index	3,78 (0,68)	3,57 (0,71)
Satisfaction index of simulator training compared to on-board training	2,21 (0,96)	-

Source: Authors.

6. Discussion.

Today, navigational simulators have become an integral part of modern maritime training programs, serving a variety of purposes and providing numerous benefits. They play a crucial role in enhancing the safety, effectiveness and capability of naval personnel by providing realistic and cost-effective training opportunities. In contemporary marine education they are used as essential tools for preparing navigators to acquire some of the pre-requisite competencies for their on board roles and effectively handle the challenges of modern marine navigation. Navigational simulator Navi-Trainer Professional 5000 is an innovative modern simulator that enables simulator training and certification for watch officers, chief officers, captains and pilots on all types of vessels. Thus, it would be important to understand the usability satisfaction of such a simulator by the students of the Merchant Marine Academy of Aspropyrgos as concerns hardware and software quality satisfaction, simulator experience satisfaction and simulator training satisfaction compared to on board training. For this purpose the students were divided into three groups based on academic semester of study, previous simulator use, and previous onboard training and a questionnaire was answered by them.

Students seem to be satisfied with hardware and software quality (total satisfaction score for hardware devices was 3,78 ± 0,76 and for software stability 3,68 ± 0,71). Similarly, students seem to be satisfied with the simulation experience as the overall satisfaction score was 3,70 ± 0,70. A high satisfaction score (above 3,50) was observed for almost all questions about the simulation experience. Students believe that simulator training offers them the opportunity to train safely in dangerous navigation situations (Q1, score 3,61 ± 1,06), learn from correcting their mistakes and train in alternative navigation scenarios (Q2, score 3,72 ± 0,99). In addition, they believe that the simulator helps to acquire skills through a better understanding of the training content and the perception of the consequences of wrong actions (Q3, score 3,77 ± 0,89). They also agreed that the simulation system offers flexibility and allows them to train satisfactorily in various navigation scenarios (Q4, score 3,63 ± 0,88). Moreover, there was a very high acceptance of the simulator's pedagogical effectiveness (Q5, score 3,82 ± 0,91). The contribution of the simulator to the assimilation of technical and non-technical skills was also evaluated very positively (Q7a and Q7b, scores 3,84 ± 0,81 and 3,63 ± 0,94 respectively). Slightly lower was the satisfaction score of simulator fidelity (score 3,47 ± 0,51), which should be correlated with student satisfaction by the comparison of simulator training with on-board training as it is shown in the last section of the questionnaire.

As mentioned above their satisfaction appears lower when we refer to the comparison of simulator training with practical onboard training, where the overall score was 2,21 ± 0,96 (Table 2). The score is even lower (1,81 ± 1,13) when students were asked whether simulator training could replace on-board training. It thus appears that academy students generally reject the idea of replacing onboard training with simulator training, a fact that should be seriously considered in any plan to increase simulator training time while reducing onboard training time.

In the results of questions about the "Hardware and Software Satisfaction Index", significant differences have been observed between students who have used any type of simulator in the past and those who have not (p-value = 0,017 < 0,05). This shows that satisfaction with simulator hardware and software is highly influenced by any previous simulation experience.

In the results regarding the 'Simulation Experience Satisfaction Index' significant differences have been observed between students of different academic semesters (p-value = 0,047 < 0,05). The satisfaction index is lower for second-semester students, who had no previous simulation experience and onboard training. The results show that both simulation experience and onboard training contribute to better use of the simulator. This is confirmed by the results for the 'Simulation Experience Satisfaction Index' between students who have taken an educational trip and those who have not (p-value = 0,011 < 0,05).

Conclusions.

The purpose of this work was to evaluate training on a modern bridge simulator. The evaluation consisted of three parts: In the first two parts it was evaluated the trainees' satisfaction with the quality of the hardware and software of the simulator and also the educational experience offered by the simulator. In addition, the students were asked whether training in such a simulator could replace practical training onboard. For this purpose, a questionnaire was drawn up and distributed to the students of the 2nd, 3rd and 5th semesters of the Bridge Officers Department of the Athens Merchant Marine Academy.

The results showed that the students are completely satisfied with the quality of the hardware and software of a bridge simulator, while previous simulation experience also contributes to this. They also seem satisfied with the training experience in the simulator, as its fidelity and pedagogical environment helps them absorb knowledge from classroom training, practice in navigation scenarios and acquire the technical and non-technical skills required for their training as merchant marine officers.

However, they feel that simulator training cannot replace onboard training. This should be taken into account by both the educational community and the shipping industry and, furthermore, taken into account in possible future revisions of STCW.

References.

Albayrak T, Ziarati R, (2010) Training onboard and simulation based familiarization and skill enhancement to improve the performance of seagoing crew. International Conference on Human Performance at Sea HPAS2010, Glasgow, Scotland, UK, 16^{th}-18^{th}June2010.

Bhaskaran B, (2018) Importance of simulators in maritime training. International Journal of Research and Analytical Reviews, 5(4) Q: 6-8.

Conceição VP, Basso JC, Lopes FC, Dahlman J (2017) Development of a behavioral marker system for rating cadets' non-technical skills. TransNav 2(2):255–262.

De Oliveira RP, Carim GJ, Pereira B, Hunter D., Drummond J, Andre M (2022) Systematic literature review on the fidelity of maritime simulator training. Education Sciences *12*(11), 817; https://doi.org/10.3390/educsci12110817.

Flin R, O'Connor P, Crichton M (2008) Safety at the sharp end: a guide to non-technical skills. https://www.taylorfrancis.-com/books/mono/10.1201/9781315607467/safety-sharp-end-p-aul-connor-rhona-flin.

Hamstra SJ, Brydges R, Hatala R, Zendejas B, Cook D (2014) Reconsidering fidelity in simulation-based training. AcadMed 89:387–392 https://doi.org/10.1097/ACM.0000000000-000130.

Hays RT, Singer MJ (2012) Simulation fidelity in training system design: Bridging the gap between reality and training, Springer_Verlag, New York.

IMO (2011) International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW) 19-78, as amended in 1995/2010. International Maritime Organisation, London, UK.

Kandemir, C., Soner, O. & Celik, M. Proposing a practical training assessment technique to adopt simulators into marine engineering education. *WMU J Marit Affairs* **17**, 1–15 (2018). https://doi.org/10.1007/s13437-018-0137-4.

Kim T-E, Sharma A, Bustgaard M, Gyldensten WC, Nymoen OK, Tusher HM, Nazir S, (2021) The continuum of simulator - based maritime training and education. WMU Journal of Maritime Affairs (2021) 20:135–150; https://doi.org/10.1007/s-13437-021-00242-2.

Massoth, C, Röder, H, Ohlenburg, H *et al.* (2019) High-fidelity is not superior to low-fidelity simulation but leads to overconfidence in medical students. *BMC Med Educ* **19**, 29. https://doi.org/10.1186/s12909-019-1464-7.

Nazir S, Overgarda KI, Yang Z (2015) Towards effective training for process and maritime industries, Procedia Manufacturing 3: 1519 – 1526 https://doi.org/10.1016/j.promfg.2015.07-.409.

Renganayagalu SK, Mallam SC, Nazir S, Ernstsen J, Haavardtun P (2019) Impact of Simulation Fidelity on Student Self-efficacy and Perceived Skill Development in Maritime Training, The International Journal on Marine Navigation and Safety of Sea Transportation, 13(3) DOI: 10.12716/1001.13.03.25.

Sellberg C, Lindmark O, Rystedt H (2018) Learning to navigate: the centrality of instructions and assessments for developing students' professional competencies in simulator-based training. WMU Journal of Maritime Affairs 17:249–265 https:-//doi.org/10.1007/s13437-018-0139-2.

Sellberg, C. Representing and enacting movement: The body as an instructional resource in a simulator-based environment. *Educ Inf Technol* **22**, 2311–2332 (2017). https://doi.org/-10.1007/s10639-016-9546-1.

Sellberg C, (2016) Simulators in bridge operations training and assessment: a systematic review and qualitative synthesis. WMU Journal of Maritime Affairs, vol. 16(2), pp. 247–263 https://doi: 10.1007/s13437- 016-0114-8.

Sharma A, Nazir S, Ernstsen J (2019) Situation awareness information requirements for maritime navigation: A goal directed task analysis. Safety Science 120:745-752.

Tsoukalas, V.D., Papachristos, D.A., Stefanakou, A.A. *et al.* Questionnaire assessment of training in a marine simulator. *WMU J Marit Affairs* **14**, 293–312 (2015). https://doi.org/-10.1007/s13437-014-0068-7.

Wärtsila (2018) Navi-Trainer Professional 5000. Navigational bridge. Version5.40 https://www.wartsila.com/.

Zghyer R, Ostnes R (2019) Opportunities and Challenges in Using Ship-Bridge Simulators in Maritime Research, Western Norway University of Applied Sciences: Bergen, Norway, 2019; ISBN 978-82-93677-04-8.

Table 8: **Appendix 1: Questionnaire.**

USER SATISFACTION SURVEY – QUESTIONNAIRE BRS

DATE(YYYY/MM/DD): _______________

GENDER: □ M, □ F AGE: _________ ACADEMIC YEAR: __________

HAVE YOU EVER USED ANY KIND OF SIMULATOR BEFORE: □ YES, □ NO

POSITION: □ STUDENT, □ TEACHER

I. SIMULATOR HARDWARE AND SOFTWARE SATISFACTION INDEX

		Very satisfied	Satisfied	Neutral	Not Satisfied	Very Dissatisfied
Hardware quality satisfaction index						
1	Operability of the system	□	□	□	□	□
2	Stability of the system	□	□	□	□	□
3	Overall equipment quality	□	□	□	□	□
Software quality satisfaction index						
1	User friendliness of the software interface	□	□	□	□	□
2	Smooth and trouble-free operation	□	□	□	□	□
3	Trainees' evaluation system and utilization of the results to improve their practical training	□	□	□	□	□
4	Output of assessment data and their exploitation for improving the training practices	□	□	□	□	□
5	Overall quality of the simulator software	□	□	□	□	□

II. SIMULATION EXPERIENCE SATISFACTION INDEX

		Very satisfied	Satisfied	Neutral	Not Satisfied	Very Dissatisfied
1	The simulator trains you, in a safe environment, in scenarios of dangerous situations that lead to accidents	□	□	□	□	□
2	The simulator allows you to learn from correcting your mistakes and train yourself to use alternative scenarios	□	□	□	□	□
3	The simulator facilitates the acquisition of skills through a better understanding of the training content and the consequences of wrong actions	□	□	□	□	□
4	The system is flexible. Facilitates changes between different scenarios (from low speed to high speed or from narrow channel to open sea navigation)	□	□	□	□	□
5	The simulator is pedagogical effective	□	□	□	□	□
6	Simulator fidelity	□	□	□	□	□
7a	The simulator helps you assimilate and apply technical knowledge and skills	□	□	□	□	□
7b	The simulator helps you assimilate and apply non-technical knowledge and skills	□	□	□	□	□

III. SIMULATOR TRAINIGN SATISACTION INDEX COMPARED TO ONBOARD TRAINING

		Very satisfied	Satisfied	Neutral	Not Satisfied	Very Dissatisfied
1	Overall satisfaction with simulation training	□	□	□	□	□
2	Simulator training provides knowledge and skills equivalent to on-board training	□	□	□	□	□
3	Could simulator training replace onboard training	□	□	□	□	□