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Improvement of Student's Engine Room knowledge and operational skills during Simulator training

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Abstract: *One of the most important tools for maritime student education is the use of simulators, which provide practical instruction under controlled conditions. This article analyzes the behavior of Marine Engineering students at the Faculty of Maritime Studies in Split and their progress in knowledge and practice achieved through training in the Kongsberg Engine Room Simulator. The research was conducted by the instructors of the Kongsberg training simulator with the students of the third (last) year of the undergraduate study of Maritime Engineering. The progress was observed during the last semester of their studies on the practical problem of manual parallel connection of diesel generators. The obtained results clearly show that the training on the simulator helped the students to combine the learned theory from several subjects into one complex and that this happens gradually during the training.*

Keywords: *simulator training; STCW; Kongsberg; engine officer; synchronization*

1. INTRODUCTION

The distinctive feature of maritime universities compared to other universities is that their curriculum is largely governed by international regulations, in this case mainly the Seafarers' Training, Certification and Watchkeeping Convention (STCW) [1]. The Faculty of Maritime Studies at the University of Split, as one of the maritime higher education institutions, falls under the same rules, which determine, among other things, the training of students in simulators as well as practical training on ships.

The Department of Marine Engineering has several simulators for different courses, including the Kongsberg K- SIM ERS -L11 MAN B&W-5L90MC VLCC Simulator [2].

Figure 1. Kongsberg Simulator Control Room

This Simulator consists of three separate rooms, two where the training is conducted (Engine Room and Engine Control Room) and an instructor's station for supervision of the exercise. The training is designed to teach students to solve practical tasks using the knowledge they have acquired. In the Simulator, students are introduced to their future profession as an Officer in charge of an engineering watch. The Officer in charge of an engineering watch (Marine Engineer or Engineering Officer) must have a good knowledge of the various machinery and technical systems, be familiar with the environment, always follow the correct procedures and react quickly to various situations, challenges or dangers to themselves or the equipment. All these qualities are taught to the students during the Simulator training and are required from them during the final exam. The situations and machinery problems (various malfunctions) they face are very similar to real-life situations and, most importantly, everything happens in real time.

In order for Simulator training to have the greatest possible effect, students must be familiar with various machines and engineering systems. Therefore, the simulator courses are held in the sixth semester (third year of study), when the students are in the final phase of their studies. Simulator training should "*contribute to the students' efficiency and experience and increase their confidence in simulated situations*" [3], or, to quote another researcher, "*to instill adequate skills to handle normal and abnormal situations*" [4]. The training and education should create the necessary difference needed for their future work.

There are two categories of engine watchkeeping personnel, divided by level of responsibility and understanding of the "bigger picture" of operating principles and potential problems. These categories are Engine ratings and Engineering officers. Their main difference lies in the level of education and thus certification [5].

Engine ratings, especially well-experienced ratings can have a good insight into daily operations and can offer good solutions to the problems at hand. In addition, they usually can successfully perform a variety of actions successfully on their own and without supervision. At the same time, engine rating's understanding of the whole process they are performing is very limited, they know how to do it, but he does not know why.

Engineering Officers should also should be able to perform a variety of actions independently and successfully without supervision. In addition, because of their education and training, they must know in detail the entire process they are dealing with and know at all times what the consequences of their actions may be. Engineering Officers must apply the skills and knowledge they have learned during their education and training in their daily work.

Because of the different training and skills, the Engineering Officer is the one who makes the decision, deals with the consequences and finally takes responsibility.

2. SYNCHRONIZATION EXERCISE

Students (trainees) are required to learn and perform a multitude of exercises during Simulator training. The most common exercises are starting various machinery systems like starting air, cooling fresh water cooling, sea water cooling, lubricating oil, fuel oil supply, ventilation and air conditioning, …, and the most important system on any ship, the generation of electrical power. Without this system, no other system on the ship works and the ship cannot perform its function. Electrical energy on ships is generated by generators, usually powered by diesel engines. Each ship must have several generators in order to be able to respond to changes in energy demand and to have redundancy due to the importance of the system. Depending on the requirements of the ship's network and the consumers, one or more generators run, connected to the ship’s busbars. Today, the monitoring of the entire system and the execution of all steps is done automatically. When the computer decides that another engine is needed, an engine is started, synchronized and connected to the ships' busbars. If a human operator wants to start an additional generator engine, he can give the computer the command to do so remotely. The whole process is relatively short and simple, especially if the automatic system is working properly, and can easily be done by either by Engine ratings or an Engineering Officer. The difference between the two is noticed when problems occur and when the system starts to function abnormally.

As described in the introduction, simulator training can be seen as a bridge between practice and theory. Assuming that students have learned the theoretical part and are ready to face the challenges of the practical simulator, the training is conducted in a way where students actively participate in various operations and problem-solving classes.

In this method of training, students are given standard ship checklists and are encouraged to carry out the exercise themselves under the guidance of an instructor. Any problems they encounter along the way can be considered learning checkpoints, because at these moments the students have to draw on their theoretical knowledge and use it to solve the problem. This is the foundation on which they will build their future experience.

The Simulator exercise recreates extraordinary situations where education and training should be beneficial. In the first part of the exercise, the computer system has failed and the monitoring of the generator and load should be done by a human. When the student determines that an additional generator is needed, he has to start a generator, synchronize it and connect it manually to the busbars.

To perform this task manually, the student must be familiar with the three conditions required to synchronize a generator (only three which the operator can change):

- The incoming generator voltage and the mains voltage must match,
- the frequency of the incoming generator and the mains should be almost the same,
- the phase sequence and phase position of the incoming generator and the mains should match.

Only when the student knows these conditions, he can perform the manual synchronization [6] of the generator.

2.1. Synchronization procedure

After connecting one generator to the ship's grid and starting and warming up another generator, the student should proceed with the process of synchronization. After turning on the synchroscope on Synchronizing Panel (Figure 2), the student must select the generator to be connected to the network (the incoming generator).

At this moment, the displays at the top of the Synchronizing Panel start to show the correct values. The first thing the students have to check is that the two voltages are the same. The voltages of the incoming generator and the mains are fixed by the manufacturers and normally do not need to be adjusted. If the student needs to perform an adjustment, they can do so by setting the AVR (Automatic Voltage Regulator).

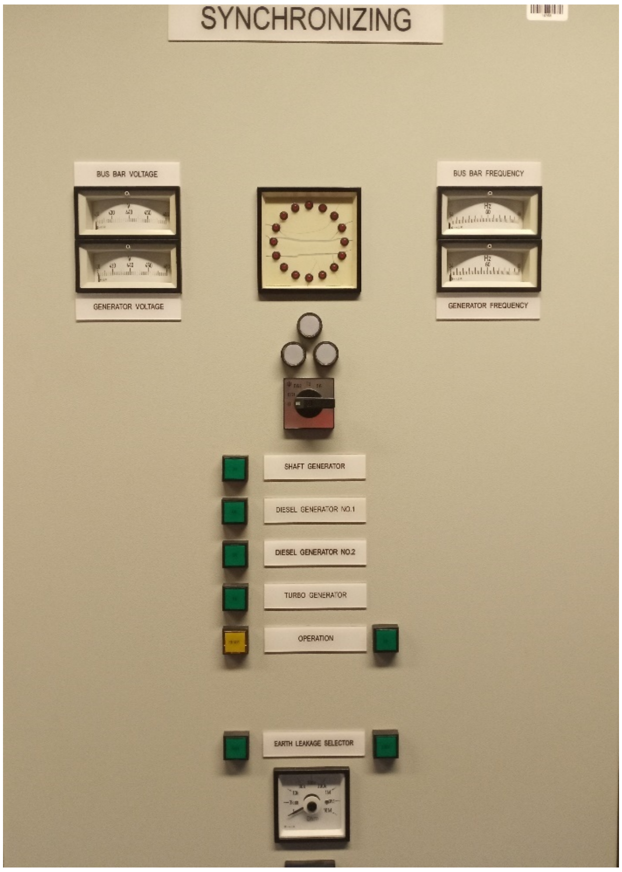

Figure 2. Simulator Synchronizing Panel

After checking that the voltages are equal in the upper left part of the Synchronizing Panel (Figure 2), you need to check and set the next condition, which is that the frequency is almost equal.

The frequency meters are in the upper right part of the panel and both frequencies should be almost the same. If an adjustment is required, you should operate the frequency adjustment handle (Figure 3) to achieve the correct results.

Figure 3. Frequency adjustment handle

The frequency of the incoming generator can also be checked by means of the rotating lights (upper part, in the middle), which indicate the difference in frequency between the generator and the mains. If the lights rotate too fast in either direction (clockwise or counterclockwise), it means that the incoming frequency should be adjusted until the rotation slows down. Once you have adjusted the frequency of the generator, you can move on to the last part of the synchronization, which is to adjust the phase and connect the generator to the mains.

The rotating lights should turn slowly clockwise, which means that the frequency of the incoming generator is slightly higher than that of the mains and the generator will start generating electricity after being connected. The generator can also be connected also if lights rotate slowly counterclockwise, which means that the incoming generator has a lower frequency than the mains. Connecting the generator in this condition will make the generator run like a motor (consuming electricity instead of generating it) and can trigger a reverse power protection trip if the power is too high or the time for such work is too long.

Another mistake students can make is connecting the generator when the rotating speed is too high. This action can lead to an aggressive connection and cause damage to the engine and generator.

After getting everything ready, the student should wait until the rotating lights arrive just before the 12 o'clock position and then connect the generator to the mains. When making the connection, the student should ensure that the load of all generators is evenly distributed [7].

3. STUDENTS' PROGRESS

The first assessment was conducted when the instructors determined that familiarization with the simulator was complete, i.e. after 16 hours of instruction. During this time, the students learned about the simulator set-up, functioning and operation principles of the simulator and performed several exercises and tasks. One of the normal tasks was to remotely connect another generator in automatic mode. They performed this task several times and were familiar with the procedure. The assessment consisted of the synchronization process after a computer failure, i.e. manual synchronization, where the students had to answer several questions to show that they understood the background of the process. At the end of the practical demonstration, the students had to answer a questionnaire with 10 questions to check their theoretical knowledge about actions.

The results of the first assessment are shown in Table 1.

Table 1. *The first assessment success rate*

Practical	Answers	Questionnaire
7/23	4/23	17/23
30%	17%	74%

Despite familiarization and theoretical knowledge, very few students managed to pass the assessment. The only area where the results were acceptable was the questionnaire, which 74% of the students passed, all other results were very poor.

At the end of the semester, the students were tested again using the same approach. The test was repeated and this time the pass rate was 100%, which can be explained by the consequences of failing the first assessment. After this part, the students are tested again, only this time the questions and tasks have been adjusted to a higher level. Besides the computer failure, there was an additional failure of the governor motor, which made it impossible to use the frequency adjustment handle. This largely complicated synchronization process, which required local manual adjustment of the governor to the value at which the incoming generator frequency is too high compared to the mains, followed by an increase in the mains frequency, creating the synchronization conditions. After synchronization and connection of the generator, the mains frequency should be set to a normal value, resulting in load sharing to the newly connected generator with a faulty governor motor.

Table 2. *The second assessment success rate*

Practical	Answers	Questionnaire
21/23	19/23	22/23
91%	82%	95%

As shown in Table 2, the vast majority of students succeeded in passing the assessment despite the relatively complex scenario. The assessment results clearly show the great progress made by the students during the Simulator course. The same results have been reached by many researchers in the maritime industry [8, 9, 10] as well as in other industries [11, 12].

4. CONCLUSION

From the assessment results, it is clear that the students have improved significantly since they started the Simulator training. The Simulator training allowed the students to apply their theoretical knowledge for the first time and "connect" it with practice.

When the parallelization problem was first presented to the students, many of them knew the definition from the textbook and the conditions for parallelization (almost 75% of the students), but did not know how to perform the operation. Only a small number of students were able to perform the required task on the first assessment, showing that theoretical knowledge alone is not sufficient. After mastering the operation procedure, theoretical and practical knowledge were merged and students were not only able to perform this and many other exercises, but also to understand the whole background of the process. This moment represents the point at which the students transform from being Engine room ratings to future Engineering Officers.

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REFERENCES

[1] International Maritime Organization (2018). *STCW convention*, available at: https://www.imo.org/en/OurWork/HumanElement/Pages/STCW-Convention.aspx, (accessed on May 25th 2022),

[2] Kongsberg K-Sim (2022), available at: https://www.kongsberg.com/digital/products/maritime-simulation/k-sim-engine/(accessed on May 25th 2022),

[3] Mangga, C., Tibo-oc, P., & Montaño, R. (2021). Impact of engine room simulator as a tool for training and assessing BSMARE students' performance in engine watchkeeping. *Pedagogika*, 93(S6), 88-100. doi: 10.53656/ped21-6s.07eng

[4] Hjelmervik, K., Nazir, S., & Myhrvold, A. (2018). Simulator training for maritime complex tasks: an experimental study. *WMU Journal of Maritime Affairs*, 17(1), 17-30. doi: 10.1007/s13437-017-0133-0

[5] Wyszkowski, J., & Mindykowski, J. (2016). Electrical, Electronic and Control Engineering–New Mandatory Standards of Competence for Engineer Officers, Regarding Provisions of the Manila Amendments to the STCW Code. *Human Resources and Crew Resource Management* (pp. 65-70). CRC Press.

[6] Strang, W. M., Mozina, C. J., Beckwith, B., Beckwith, T. R., Chhak, S., Fennell, E. C., ... & Waudby, W. P. (1996). Generator synchronizing industry survey results. *IEEE Transactions on Power Delivery*, 11(1), 174-183. doi: 10.1109/61.484014

[7] Vučetić, D. (2012). *Brodski električni sustavi*. University in Rijeka, Maritime Faculty, Rijeka. (in Croatian)

[8] Øhra, M. (1988). *Pedagogical Aspects of Simulator Training*. In International Users Conference, Newcastle Maritime Simulators & Training System Kongsberg Norcontroll System AS.

[9] Harald, K. (2008). Improving Pedagogical Value of Engine Room Simulators through Advances in e-Learning, Instructor Control and Licence Management. *Marine Engineering*, 43(3), 349-354. doi: 10.5988/jime.43.3_349

[10] Bratić, K., Vidović, F., & Stazić, L. (2020). *Use of Merlin System and Recorded Instructions in Engine Room Simulator Training*. In International Scientific Conference Technics and Informatics in Education (pp. 282-285).

[11] Bergamo, P. A. D. S., Streng, E. S., de Carvalho, M. A., Rosenkranz, J., & Ghorbani, Y. (2022). Simulation-based training and learning: A review on technology-enhanced education for the minerals industry. *Minerals Engineering*, 175, 107272. doi: 10.1016/j.mineng.2021.107272

Hauschild, J., Rivera, J. C., Johnson, A. E., Burns, T. C., & Roach, C. J. (2021). Shoulder Arthroscopy Simulator Training Improves Surgical Procedure Performance: A Controlled Laboratory Study. *Orthopaedic Journal of Sports Medicine*, 9(5). doi: 10.1177/23259671211003873