

A Comparative Study of Training Methods for Training and Education of Marine Engineering Students of IAMU Universities

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ABSTRACT

The major role of the marine engineering department of IAMU member universities/faculties is to provide their undergraduate students with effective and highly leveled education and training to be a highly competent marine engineer.

Standing at this point of view, the authors have considered the effective training method in compliance with STCW'95 convention and the Codes. Without doubt, the traditional methods, using ships in service and/or training ships, to provide practical experience have long been recognized as the effective training method by marine engineering institutions. On the other hand, engine room simulators have recently begun to attract notice as a new training method because of the several advantages over the traditional methods.

In the first part of this paper, a comparative study among the training methods utilizing a ship in service, a training ship and an engine room simulator is carried out, by taking account of the merits and demerits of each training method in view of reality, repeatability and types of training concepts. Consequently, the way to organize the most effective training method for IAMU member universities/faculties are proposed in the first part of the paper.

In addition to this, the authors also considered additional training programs which aims higher competencies for maritime institute graduates than the minimum requirement for the competences shown in the tables A-III/1 and A-III/2 in the Code of STCW'95. In the second part of the paper, the authors also discuss what an additional competence should be needed for the graduates from advanced maritime universities and propose a competence for managing the risk in machinery space on board ship as the additional competence for students of IAMU member institutions.

1. Introduction

Importance of the safety at sea and preserving the sea environment has been increased in the operations of the ships during last decades. To achieve a safe navigation and preserve the environment, ships are equipped according to the IMO regulations and standards.

On the other hand, sea personnel are the people who fulfill these tasks by using the equipment. Therefore, the training of the seafarers for updated information and for better skills also became a very crucial issue. Even though there are new regulations and guidelines, this still does not reduce the accidents which 80% of still caused by human mistakes. The tasks expected from the sea personnel to provide a safe navigation are:

- ✧ To perform their duties without risking the safety of the ship,
- ✧ To be able to take action fastly and reliably when any unexpected event occur.

Success of acheving these tasks are based on the level of the personnel's knowledge and skills. The lack of these causes the personnel not being able to use the equipments appropriately and effectively that also increases the risk in an abnormal situation resulting more harm at the incident.

In this paper, two main targets are focused regarding to the improvement of the training and education of marine engineering students of IAMU universities. These are:

- (i) to propose a useful method to organize the most effective training method for the students of the Marine Engineering departments of IAMU institutions.
- (ii) to make it clear what the difference between the minimum requirement for the marine engineers' copetences in accordance with STCW Code A and the requirement to be a qualified marine engineer in view of IAMU objectives.

2. Competency Levels and Training Methods According to STCW95

Competency Levels of Engineer Officers for ocean going vessels are basically classified into two categories in STCW Code A-III as follows [1]:

- ✧ Operational Level
- ✧ Management Level

For Operational Level, Table A-III/1 defines the specification of minimum standard of competence for officers in charge of an engine watch in a manned engine room or designated duty engineers in a periodically unmanned engine room. For Management Level, Table A-III-2 defines the specification of minimum standard of competence for chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more.

To demonstrate the competencies for both operational and management levels, different types of training methods recommended in STCW95. These training methods based on STCW95 could be listed as the following:

- i. Classrooms/Workshops/Laboratories
- ii. Ships In Service (Merchant Ship)
- iii. Training Ship
- iv. Engine Room Simulator (ERS)

As suggested in STCW'95, labs and workshops could be used to demonstrate some of the competencies. In this paper, this method is considered as the base level and the fundamental teaching methodology for maritime institutions. Therefore, the workshop and lab training or teachings are not considered as an alternative method to the other three.

For the purpose of this paper, the following assumptions are made regarding to the types of training

methods under study:

- ✧ Ship in-Service is an ordinary merchant ship that comply with IMO regulations and standards [1],
- ✧ Training ship has both the navigation personnel and training instructors
- ✧ Simulator is a Full Mission Type [2].

In view of these assumptions, summary of merits and demerits of three training methods – Ship in Service, Training Ship and Engine Room Simulator- are considered and listed in the following sections.

2.1 Ships in Service (M. Ship)

- Classical method that is still preferred by many institutions
- “Actual working place” after school
- Training record book is provided with guidelines
- Having the first priority of the M.Ship is commercial, no active responsibility may be given to trainees
- Difficulty of training some subjects
- Difficulty of finding an appropriate commercial ship
- Unscheduled events and learning
- Difficulty of evaluation
- Dependence on teaching skills of Chief or Second Engineers - difficulty of standardization.

2.2 Training Ship (T. Ship)

- Navigation is based on the training curricula,
- A “good training program” may easily be achieved.
- Actual working place after training is similar
- Having training personnel, possibility of standardization.
- Still some malfunctions cannot be implemented and some certain responsibilities cannot be given to the students
- too costly

2.3 Engine Room Simulator (ERS) Training

- The operations of the machinery are simulated as close as possible to their actual conditions,
- Training for both normal and abnormal condition “repeatedly”
- Cost-effective
- Time effective
- Flexible and controlled schedule of the training curricula,
- Controlled evaluation of the students.
- Possibility of setting standards for globalization
- Even though ERS simulates the real engine room environment and systems, still “ERS is not the actual working place of trainees”

3. EVALUATION AND COMPARISON OF TRAINING METHODS BASED ON STCW95

Having the suggested training methods in STCW95, the authors' intention is to compare these methods based on some criteria as well as in view of the merits and demerits of these methods explained in the previous

section. In this section, to perform a detail study and evaluation, each of the following four criteria are considered for comparison of the training methods against each other:

- ◇ Reality,
- ◇ Repeatability,
- ◇ Type A,
- ◇ Type B.

The first two criteria, Reality and Repeatability, are basic expectations from a training method to have to train marine engineering candidates. While the ERS training has so many advantages over T.Ship and M.Ship training, it is authors' interest to find out how ERS training is good when reality issue is considered. Also, authors' another interest is to compare ERS training with M.Ship and T.Ship that have actual ship environment but provide limited as well as unrepeatability training subjects.

The first competence required for a marine engineer is to keep all of the machines and systems under the normal condition. This is valid for both operational and management levels. In order to achieve this competence, marine engineers have to know what normal condition is and to be able to forecast the malfunctions when an abnormal condition is monitored. To achieve this, the purpose of the training is to keep all of the machinery under the normal condition. This type of training criteria will be defined and called as "Type A Training" throughout this paper.

The second type of competence is to recover the abnormal condition to normal condition based on the knowledge and experience. For this competence, marine engineers have to know the difference between the normal and abnormal condition, the process to recover and should not fall into the panic condition when an abnormal condition occurs. In view of the skills and experience needed to recover the abnormal condition to the normal one, set of repeated training with abnormal condition is needed. This type of training criteria will be defined and called as "Type B training" throughout this paper.

Since one of the purposes of this paper is to propose a way to organize the most effective training method, the procedure of comparison for management level will only be shown as an example with some explanation in the following section. The detail procedure for both operational and management levels are referred to described in another paper presented by the authors [3].

3.1 Comparison of Methods for Demonstrating Competence (Management Level)

Based on the four criteria explained before -reality, repeatability, Type A, and Type B training-, each competence under column 1 of Table A-III/2 of STCW'95 is evaluated, and grading letters A, B and C are assigned based on the merits and demerits of each training methods. The meanings of these grades are:

- A – Better: mostly preferred type of training
- B – Good: sometimes preferred type of training
- C – Average: rarely preferred type of training

The results of this evaluation for Management Level are inserted into a similar table as in Table 1 and the summary of the justification for the evaluation is described below.

When reality is considered, M.Ship is the better training method comparing to T.Ship or to ERS training methods because that is the actual environment where the trainees will perform their duties under full responsibility. T.Ship is also very close in covering most of the competencies. ERS is considered that its

environment reflects the reality less comparing to M.Ship or T.Ship and “C” or “B” letters are given for the competencies. This is because no matter how the simulator is well designed to make the environment close to real, it is still the simulator and it is very difficult to create the same training based on reality. Only some competencies, such as operating control systems, might be implemented close to reality in ERS training.

Table 1. Comparison Table of Methods for Demonstrating Competence (Management Level)

Competence	Reality			Repeatability			A-Training			B-Training		
	M.S.	T.S.	ERS	M.S.	T.S.	ERS	M.S.	T.S.	ERS	M.S.	T.S.	ERS
Marine Engineering												
Plan and schedule operations	A	A	B	C	B	A	A	A	A	C	B	A
Start up and shut down main propulsion and auxiliary machinery including associated systems	A	A	B	B	B	A	B	A	A	C	B	A
Operate, monitor and evaluate engine performance and capacity	A	A	B	C	B	A	C	A	A	C	B	A
Maintain safety of engine equipment, systems and services	A	B	C	C	B	A	B	A	A	C	B	A
Manage fuel and ballast operations	A	B	C	B	A	A	B	A	A	C	B	A
Use internal communications systems	A	A	B	B	A	A	B	A	A	C	B	A
Electrical, Electronic and Control Engineering												
Operate electrical and electronic control equipment	A	A	B	C	B	A	B	A	A	C	B	A
Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition	A	A	C	C	B	A	B	A	A	C	B	A
Maintenance and Repair												
Organize safe maintenance and repair procedures	A	B	N/A	B	A	N/A	B	A	N/A	C	B	N/A
Detect and identify the cause of machinery malfunctions and correct	A	A	C	C	B	A	C	B	A	C	B	A
Ensure safe working practices	A	B	N/A	C	A	N/A	A	A	N/A	C	B	N/A
Controlling the Operation of the Ship and Care for Persons on Board												
Control trim, stability and stress	A	A	C	B	A	B	B	A	A	C	B	A
Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea and protection of the marine environment	A	A	C	A	A	A	A	A	A	C	A	A

Regarding to repeatability, ERS training is better since it provides the possibility to implement almost all of the training topics for competencies repeatedly. T.Ship is also good for repeatability since the schedule of T.Ship is controlled according to the training program. In M.Ship, only some competencies such as normal watchkeeping operations repeatable because most of the schedule of engine room operations cannot be planned based on the training program. Also, repeating malfunctions is not possible in M.Ship. On the other hand, M.Ship is the most effective training method for maintaining a safe engine watch since a regular and systematic engine watch twice a day has to be maintained for a long time of navigation.

In view of Type A training, T.Ship and ERS training is found better since the reality is not under consideration and almost all competencies can be covered. In both ERS and T.Ship training, students are

assigned with specific responsibilities and instructor makes sure that all competencies for operational level are satisfied. Whereas, students are most of the times assumed to be observant and active participation under an instructor cannot be given during the training in M.Ship, therefore “B” letter is assigned for all competencies for M.Ship.

Considering Type B training, the training program for creating malfunctions cannot be implemented in M.Ship training. T.Ship is still a real ship and it is not possible to create malfunctions and control the program for the training. On the other hand, ERS training is almost perfect for this type of training since there are no actual breakdowns when malfunctions are created and associated troubleshooting skills are developed. For example, handling the panic and stress can be trained only in ERS training. Therefore, letter “A” is assigned for almost all of the competencies under the ERS column of Table 1.

3.2 Results on the Comparison of Training Methods based on STCW95

In order to summarize the evaluation shown in Table 1, the grading letters in the table are converted into numeric values based on the following criteria:

$$A \geq 2.5$$

$$1.5 \leq B < 2.5$$

$$C \leq 1.5$$

The resulting numerical values for each training method and competencies collected and averaged. Final numeric values are converted back to the grading letters based on the same criteria. After having letters that includes all criteria, namely, reality, repeatability, Type A, and Type B, a summary table is reconstructed as seen in Table 2.

Table 2. Summary of Comparison Table for Demonstrating Competence (Management Level).

Competence	T-Ship	M-Ship	ERS
Marine Engineering			
Plan and schedule operations	A	B	A
Start up and shut down main propulsion and auxiliary machinery including associated systems	A	B	A
Operate, monitor and evaluate engine performance and capacity	A	B	A
Maintain safety of engine equipment, systems and services	B	B	A
Manage fuel and ballast operations	A	B	A
Use internal communications systems	A	B	A
Electrical, Electronic and Control Engineering			
Operate electrical and electronic control equipment	A	B	A
Test, detect faults and maintain and restore electrical and electronic control equipment to operating condition	A	B	A
Maintenance and Repair			
Organize safe maintenance and repair procedures	A	B	N/A
Detect and identify the cause of machinery malfunctions and correct faults	B	B	A
Ensure safe working practices	A	B	N/A
Controlling the operation of the ship and care for persons on board at the management level			
Control trim, stability and stress	A	B	B
Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea and protection of the marine environment	A	A	A

The resulting tables can help an institution to effectively organize the available training methods in the curricula. For example, at ITUMF, T.Ship is being used as the basic level for recognizing the parts, systems,

and operations visually under the instruction. In general, these training methods could be used for the following purposes:

T.Ship: for recognizing parts, systems, and operations visually.

M. Ship: for practicing the engine room operations in the actual working environment.

ERS: to offer more advanced trainings such as to increase troubleshooting skills of the trainees.

4. Additional Competences for being a Qualified Engineer Officer

An article of IMO NEWS said, “One of the key differences between STCW’95 and the previous Convention is the emphasis on competence rather than knowledge”[4]. In the light of this sentence, it is reasonable to suppose that our proposal to organize the training method is based on the competence even for the management level. In other words, the proposed method is useful to organize the training program for engineer officers’ licenses. Considering the role of IAMU member universities as leading the Maritime Education and Training (MET) in the world, it is just a minimum requirement to organize and implement the training program for officers’ license even if the program is the most effective one.

In order to offer the additional competence mostly based on knowledge level for being a highly qualified engineer officer, it is worth considering the procedure to restore to the normal operational condition after facing a severe accident in the machinery space. In such a case, engineer officers first have to find out the cause and measure the level of the incident using their knowledge and experience, which are mainly covered as the competences shown in the table A-III/1 and 2 of STCW95.

In addition to these competencies, teamwork among the engineer officers and the leadership of the Chief Engineer officer as well as the risk management to predict and prepare for the accident are absolutely indispensable because the machinery system of a typical modern ship is very much complicated.

On the other hand, it is common understanding that facing to a severe accident easily creates ‘Panic’ that often leads the increase in the human mistakes in spite of the theoretically given competences. Furthermore, fatigue and stress, which sometimes are impossible to prevent perfectly because of the nature of the human being, increase the human errors additively. However, the training for having the knowledge and experience of what situations creates and leads to make human errors may create qualifications to control panic, stress, and fatigue and to focus on what to do correctly under these difficult circumstances.

Based on the above discussions, the authors propose the following additional competences for being a qualified engineer officer;

- ◇ Teamwork among engineer officers (how to be part of the team)
- ◇ Leadership (how to organize the team)
- ◇ Safety culture and management of the risk in the machinery space (how to predict and prepare for an accident)
- ◇ Aspect of the human error (the causes, behaviors and results etc.)
- ◇ Communication aspects (how to communicate in multicultural environment with better communication skills)

The authors would like to point out that education and training curriculum to demonstrate these additional competences have to be provided to the undergraduate students of IAMU member universities.

5. CONCLUSION

The purpose of the comparative study discussed in this paper is not to decide what training method is the best for all of the competencies needed to be a qualified marine engineer based on our results obtained herein. Rather, to have some comparative results for the training types so that some recommendations to Maritime Institutions can be made.

Maritime institutions around the world are using different types of training to comply the same competencies as explained in STCW'95 and the Code. Because of these differences, it was authors' special interest to find out the most efficient training method and take actions based on that. The results in this paper show that one institution can use the available training methods efficiently with guidance of such comparative tables.

Based on the results of the previous sections, it is concluded that ERS training could be used to give marine engineer candidates higher-level qualifications discussed and proposed in this paper. For example, the use of ERS for team-management and for communication skills could very efficiently be arranged because of the opportunity of preparing the scenarios based on the type of the training and education. Furthermore, by providing a scenario of simulated severe accidents in the machinery space, marine engineer candidates will be able to experience the situation without any damage to training equipments. Through this type of training, marine engineer candidates can easily learn the safety culture, how to manage the risk and the aspect of the human error. Simultaneously, the behaviors of the trainees during this type of training recorded on ERS will provide the academic staff of the department of marine engineering with opportunities to develop research topics in order to prevent mistakes by human errors. Therefore, authors' proposal is that IAMU institutions should introduce and extensively use the state-of-the ERSs in the undergraduate curricula for both students and academic staff at IAMU universities.

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