Team organization and independent learning in engine simulator laboratories

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Abstract

This paper presents the continuing development of a teaching methodology for engine simulator lab classes in which independent learning and team organization play integral parts. The implementation of these methods has dramatically improved student learning in our steam and diesel simulator classes. We wish to share our findings as we continue to experiment with new methods to improve the program and work toward a standardized set of lessons and teaching methods for engine simulation instruction. We are not suggesting that the methods utilized by our program are the ideal way to teach for all institutions, but it is our hope that this paper will be a springboard for discussion and the sharing of ideas.

Keywords: engine simulator, engine simulation, teamwork, instruction, assessment.

1 Introduction

The California Maritime Academy utilizes part-task and full-mission engine simulators to prepare its engineering students to take an active role in industry upon their graduation from the institution. (Section 2 explains in detail the differences between part-task and full-mission simulation trainers). To fulfil this goal the teaching methods used for training must evolve to meet the complexity and challenges of the modern marine power plant. In order to improve the methods utilized, we first determine the most important skills for our students to develop:

- Teamwork
- Personnel management

- Critical thinking
- Working knowledge of instrumentation (Human Machine Interface)
- Working knowledge of engineering systems
- Working knowledge of equipment procedures

In sections 3- 5 we examine the methods used to teach each of these skills, and determine how these methods could be improved. In section 6 we discuss methods of assessing the students. We look to standardize teaching methods, so as to give consistent and uniform training to all students, and address this issue in section 7. Finally, to improve our program, we need to close the feedback loop by formulating a more effective evaluation system. We aim to continually improve student learning and leave the students feeling empowered by the evaluation process. Section 8 discusses student feedback and future work on this project.

2 Engine simulation laboratory physical layout

Engine simulation laboratories at CMA utilize full-mission and part-task simulation training classrooms to increase the student learning experience. Each has its own inherent advantages and disadvantages and both systems utilized together can greatly enhance student training compared to either system used strictly by itself.

A part-task trainer is a software program that resides on a personal computer and all interaction takes place within the PC environment. It is very useful for classroom discussion and provides a suitable environment for the instructor to deliver lectures. Individuals also find the part-task trainer convenient to practice scenarios by themselves. Student teams can use the part-task trainer during planning sessions prior to full-mission laboratory sessions greatly enhancing their chances of success. The difficulty with part-task trainers is that they do not provide the realism of a full-mission trainer and are not suitable for teaching team organization. They can also be misused where the students learn by experimentation without understanding the process or equipment. This video game mentality can be very counterproductive with the student learning bad habits and forming conclusions on misconception and poor information. Students need guidance through every aspect of their training to prevent them from forming conclusions based on a “point and click”, “try it and see” type of experimentation.

Full-mission trainers are computer based systems with laboratory spaces which simulate control room and engine room spaces as would be found on an actual vessel. Full size cabinets are used to simulate some of the control panels and control consoles that would be present in an actual power plant. Full-mission trainers have the following advantages:

- Add a level of realism which can excite the imagination and interest of the student.
- Train the student to mentally process the complex and varied information which is provided by a modern control console with all its instrumentation and controls.

- Provide a suitable environment for teaching the following skill sets which can only be learned by the interaction in a group setting:
    - Team organization and management
    - Personnel utilization for maximum effectiveness
    - Crises management
    - Critical thinking

The disadvantages of a full-mission trainer, of course, are both its complexity and cost. In addition, full-mission trainers are not available to the students without an instructor being present.

3 Class design and structure

Students enrolled in the engine simulator classes at the California Maritime Academy (CMA) are equipped with experience on the school's training vessel and thus are familiar with the engineering systems of a medium-speed diesel vessel. The simulator classes must first teach the engineering systems, as a large percentage of the students taking these classes have not yet been given detailed instruction in the engineering systems of a steam or slow-speed diesel ship.

To help the students learn the basic systems, a five-step lesson plan has been developed where the students will individually, and as a group, bring the engineering plant from a dead plant condition to a full sea-speed condition. During these five steps a comprehensive start-up procedure for all engineering systems and equipment is covered.

The engine simulation courses at CMA are taught over a fourteen week semester as weekly two-hour sessions. A two-week cycle is maintained through the first ten weeks of the course. In the first week of each two-week cycle, students learn about the individual systems and procedures used for system start-up via electronic presentations and instruction on the part-task trainers. Because assessment of the students is an important aspect of the learning process, the second week is dedicated to student testing and assessment. The students are evaluated both individually and as a group by three different evaluations (see section 5 for details).

At the end of the ten-week simulator familiarization cycle the remaining four weeks are utilized to expose the students to common engine room casualties using the full-mission trainer. Field trips to a diesel vessel -- where the students can see and experience the engine room of a power plant -- also incorporated whenever possible.

4 Independent learning

Students are expected to take an active role in learning by preparing for each lecture and simulator session. A manual containing documentation of simulator systems, proper engineering procedures, and general engineering information is provided to each student at the start of the semester. The electronic presentations are also available (via intranet) for review before each lecture. The presentations cover the following aspects:

- Function and operation of the engineering systems that the student will encounter on the engine simulator.
- Engineering systems that are not incorporated in the engine simulator but could be normally encountered on commercial ships.
- Operational procedures for proper equipment start-up.
- Operational checks and procedures that should be performed to assure proper system operation.
- Troubleshooting techniques for various engine or system problems that could be encountered.
- Engineering safety and procedures that must be followed to maintain a safe working environment.

The electronic presentations contain illustrations of actual shipboard engine equipment for comparison with the related simulator equipment. Students are also encouraged to submit pictures from their commercial cadet cruises for addition to the class material. The addition of engine room pictures taken by students has dramatically improved the quality and depth of the presentations.

After a fifty minute lecture using the electronic presentation, students are given training on the part-task trainer by the instructor. It is important that the students are given enough information to understand and manipulate the engine simulator, but it should be understood that the information given to the students should not be so complete that they memorize procedures rather than work through a problem set. The class time is spent talking to the students about how the engineering systems function, proper methods of equipment start-up, and system problems that can occur. The instructor should not give an exact click-by-click tutorial on how to work the simulator. True understanding of systems requires that the students take the time on their own to work through the procedures and find solutions to any problems that occur.

In addition to the verbal instruction, the students are given a written procedure to follow which should help them perform the procedures with practice. Students are given the written procedure electronically at the start of the course. The written procedure is designed to give the students enough information to complete their task, but is not specific about how to manipulate the simulator.

To prepare for the following assessment session, students are expected to practice simulator operation on the part-task trainers outside of normal class time. To help the students achieve this goal, the part-task trainer classroom is open until 8 p.m. in the evening six days of the week and is staffed with a student proctor who is competent with the engine simulator and can help with any problems that they might encounter.

In addition to class work, student teams are assigned emergency situations to research outside of class. Each group is required to give a verbal presentation as to how the situation could be avoided and what procedures should be followed to respond to the emergency.

5 Team organization

Individuals must be able to work effectively as a member of a team in order to succeed. The students should learn this as part of their training. Indeed this has been common practice with bridge simulation training for a number of years and should be just as important a segment of training for engine simulation. Those students who form strong effective groups far surpass those who do not. The difference in performance and confidence levels can be striking.

The key to successful integration of team management and interpersonal strategies is that the course instructor too must have extensive experience in managing personnel in an engineering plant environment. In addition, having specialized training in personnel management techniques would be beneficial. Each student team is made up of individuals with different strengths and weaknesses, and the instructor acts as a mentor through the process, giving them useful techniques and guidance as the course progresses.

Student progress in team building is evaluated every two weeks by the instructor during the full mission simulation. Experience has shown that most students require four to five weeks to coalesce into a team. Any group that does not form a team by the sixth week will usually be left behind academically by the other groups. At the midpoint of the course it is important that the instructor work separately with those teams that are having trouble forming and ascertain what problems exist that are preventing the group from being successful. Intervention by the course instructor can be critical to student learning and engagement at this point.

It should be noted that an important element of the team building process is that the students must be challenged by the simulator to the point where they realize they cannot succeed if they do not work together. To build effective teams takes considerable effort and cooperation among all the students. This can sometimes be difficult as one member of the team will invariably want to ride on the shirttails of the other students while others want to run the whole show. The realization that teamwork is vital to their success will prompt the students into taking the necessary steps to follow through and truly form their team. This process can be difficult and frustrating to the students in the beginning, but once their team has been formed and they see the benefit of their efforts they come to understand the necessity of the process.

In the full-mission simulator, students are divided into teams in which they are assigned titles and responsibilities as would be encountered in industry. Teams are expected to meet and discuss their operating plans for each lesson before entering the full mission simulator. Students are graded relative to the responsibility of the position they hold and their ability to work as a team. In the first few scenarios, it is vital that the students are challenged enough so that failure is assured without effective teamwork. This can be accomplished very successfully by requiring the students to bring the plant up and manoeuvre the vessel out to sea with all plant automation in full manual operation. For the purposes of this discussion, a scenario for the steam simulator will be used as an example. The student positions are broken up into the following engineering positions and examples of their duties are given:

- First-assistant engineer is in charge of the engine room whenever the Chief Engineer (course instructor) is not physically present. This individual manages all other engine room personnel and assigns them their duties. The First-assistant engineer would normally respond to engine telegraph orders and control the main engine throttles during manoeuvring.
- Second-assistant engineer is in charge of the boilers. The duties of this individual could include controlling the firing rate and combustion air flow to both boilers manually while controlling steam flow rate to the feed pump to maintain the feed water pressure at its proper level.
- Third-assistant engineer is in charge of the electrical power generation & distribution. This individual also is required to fill out the engine room logbook and bell book. As an example, this individual's other duties could include the following:
    - Controlling the voltage of the main switchboard by adjusting generator excitation manually
    - Controlling the water level in the main condenser by adjusting the condensate recirculation control valve manually
- Fireman who stands at the boiler front to light-off and secure fuel oil burners whenever boiler burner management is in manual control.
- Watertender who is required to control steam drum water level at the upper engine flat whenever water level is being manually controlled.
- Oiler whose duty is to record pressures and temperatures throughout the plant for entry into the logbook. As an example this individual's other duties could include the following:
    - controlling the D/C heater level by regulating make-up feed water
    - controlling 35# auxiliary exhaust and 150# auxiliary steam system pressures with manual steam regulating valves

The complexity of manoeuvring a steam vessel with all of the automation in manual can be challenging for the students in the beginning, but becomes second nature within a very short period of time.

As the students run through the set scenario each week the instructor watches for any mistakes that the students make in the procedures and ensures that the simulator responds in a fashion which would be appropriate for the situation. For example, if the students were to run a positive displacement pump without an open discharge valve, it might be appropriate for the instructor to trip the pump electrically after a short period of time. At the conclusion of the lab session a short debrief should be held to discuss:

- First assistant engineer's management skills
    - Effectiveness as a leader
    - Manpower utilization
    - Crises management

    - Organizational skills
- Teambuilding techniques
- Scenario problems and proper corrective actions
- Performance of all students

The number of students present during full-mission training is critical and an excessive number of students will destroy the team-building process. Due to the inherent complexity of the steam simulator, six students can be accommodated in a training session. In the case of the diesel simulator, six students would be excessive, so they are broken up into two groups with three students each.

6 Assessment of student knowledge/abilities

The students are evaluated both individually and as a group by three different evaluations:

- Written essay examinations which give a detailed look into each individual student's competence and understanding of the covered material.
- Testing on the part-task trainer which gives an evaluation on each individual student's competence to operate and manipulate the engine simulator. Since the testing covers a set scenario which has been laid out by the instructor at the beginning of the semester, the student has ample time to practice during the week prior to testing. The simulator software has been programmed to evaluate the student's progress automatically, and a copy of the computer snapshot is saved for later review by the instructor.
- Full-mission evaluation in which the students work through a set scenario. This portion of the evaluation tests the students' abilities to work effectively as a team, utilizing critical thinking principles and personnel management skills; and the ability to prioritize during high stress situations. An evaluation form has been developed so that the instructor has a written evaluation of each lab session which is retained for grading purposes.

The evaluation form utilized during the full-mission lab section purposefully evaluates primarily the performance of the First-assistant engineer. The First-assistant engineer is responsible for the abilities of the team as a whole. The position of First-assistant is rotated between all the students with each student being assessed twice during the duration of the course. All other participants are evaluated on their ability to follow direction and attentiveness, but this evaluation is minor compared with that of the First-assistant.

7 Standardized lessons

A particularly challenging aspect of the engineering programs at Cal Maritime is that the dramatic increases in the number of students in the curricula over the past five or six years have resulted in a corresponding increase in the number of instructors needed to teach all of the various simulator classes. Consequently, we have experienced many different teaching methods of many instructors. This has underscored the need for rigorous consistency among all those involved with a particular course – not only for the course material, but also for the goals of the program in general. There is a great deal of pressure on faculty to efficiently use the limited time available for simulation training, while at the same time not compromise the goals of the program, namely, that the student fully comprehends the material.

The solution to integrating the styles and philosophies of all instructors of simulator courses lies first in coordination with the program as a whole. It is therefore crucial that all instructors not only are working toward the same goals for the semester, but also that the same information is passed on to all students successfully. The primary means by which all students can be assessed equally, regardless of instructor, is through the use of standardized scenarios and course outlines. All students taking a course in the Steam Simulator, for example, should be required to perform the same assessment exercises. The full development of these standard assessments is a work in progress. The exercises currently in place accomplish the following goals (steam and diesel):

- Thorough knowledge of all ship systems and layout. Without this comprehension, trouble-shooting, team management, and casualty management exercises cannot be conducted
- Thorough understanding of the inter-relationships between the various systems
- Ability to bring up full electrical power on the ship, from a dead buss to normal operation
- Ability to bring the vessel's propulsion machinery from cold iron to full-away sea voyage and back to a docking condition
- Full utilization of all Engineering Resources at hand (personnel in the plant, as well as those on the "bridge")
- Proper adherence to laws and regulations regarding safety, etc.
- Recognition of any legitimate method the student uses to complete the exercise, as long as it poses no threat to personnel, machinery, environment, or legalities

The exact form of these assessments is still taking shape and is largely dependent upon the faculty's familiarity with the idiosyncrasies of the simulators themselves. In all cases, any deviation from safe operating procedures is severely penalized. However, students must not be penalized for following their own system for the assessment if their system adheres to engineering principles. Experience has shown that those students who truly understand the task at hand have no trouble building their own safe procedural systems, whereas those who do not understand are bound to trying to memorize check-off lists or other step-by-step instructions. Rather than monitoring valve positions, motor status etc., it is often more beneficial from a training perspective when actual temperatures, pressures and other indicators are recorded.

Our experiences also suggest that the more engagement the student has with his/her team-mates, the more each member of the team benefits – both intellectually and socially. Therefore, scenarios and assessments are structured in such a way that the final outcome is not necessarily the most important goal of the exercise. Rather, a high score can be achieved simply by demonstrating that the aforementioned program goals have been met and by the student(s) reacting to problems encountered flexibly and in a coordinated fashion. The instructor too must be able to react flexibly to the training situation at hand, as well as be familiar enough with the simulator to ensure realistic – and thus valid – plant response

8 Student feedback and future work

To develop better course assessment tools, we have begun to survey students at the time of assessment (the second week of each two-week cycle). Sample survey questions are as follows.

1. Of the knowledge you have applied to today's lesson, how much has come from:
    a. Reading the manual
    b. Asking your instructor for help
    c. Asking the student proctor for help
    d. Talking with team-mates
    e. Talking with other peers
2. What did you do to prepare for the lesson? (Check all that apply.)
    a. Read the manual
    b. Practiced the part task trainer on your own
    c. Asked the student proctor for help with the part-task trainer lesson
    d. Practiced the part-task trainer with friends/team-mates
    e. Review the symbols used
    f. Get is in the full mission simulator as a team
3. Did you meet with your team to prepare for the lesson? If so:
    a. Where, and for how long did you meet?
    b. What did you discuss? (project steps, division of labour in the simulator, etc.)
    c. Do you feel that it helped you succeed with the lesson?
4. Do you feel that you have been given enough information to succeed with the lesson? If not, what was missing?
5. Could you confidently teach this lesson to a friend?
6. In general, do you feel the expectations of you are appropriate?
7. Do you find it difficult to treat the computer as a piece of machinery? (Does it seem more like a video game?)

We expect the responses to these questions to help us to continue to improve our teaching methodology, as well as make the students aware of what they can be doing better. Knowing now, for instance, that the students initially view the part-task trainer as a video game, we can remind them of the real-world consequences of their trial and error clicking.

9 Summary

It is our hope that with this paper we have opened a discussion on teaching methods for engine simulator lab classes. Engine simulation is evolving at the California Maritime Academy by empowering the students to accelerate the learning experience through teamwork and independent learning.

Team organization has the greatest potential for increasing student learning and understanding of the material. It is improved by effective instructor mentoring and guidance on techniques that promote teamwork.

To encourage independent learning, course material should be designed so that students can work independently of the instructor. Avoid detailed check-off lists which encourage students to memorize procedures. Part-task trainers must be available to the students outside of normal class time to promote individual study. The instructor should familiarize the students with the part-task trainer during the lecture to encourage its use.

Engine simulation training will continue to improve into the future due to the work being accomplished to standardize training and improvements in student feedback through the course evaluations.