FILLING THE VOID: TRUE ASSESSMENT OF STUDENTS' ACTUAL OPERATIONS KNOWLEDGE

GREEN W. SCOTT

California Maritime Academy, USA

ABSTRACT

The goal of this paper is to illustrate a way by which the practical limitations of modern engine simulators and their automated assessment systems may be overcome, thus gauging the true knowledge of the student engineer. The technical capabilities of engine plant simulator systems have provided instructors with relatively consistent means through which student progress and performance can be monitored, but at the same time have given the student the ability to “play the game” according to a predefined metric. It is often difficult for the instructor to determine whether the success was to true comprehension or simply to memory.

A wide variety of strategies have been developed to demonstrate a student mariner’s “qualification”, but we are still frequently left with the question of whether or not a student’s performance on an automated assessment truly reflects his or her knowledge. For standard tasks, one-time exercises against a benchmark test can be useful to gauge knowledge, as long as the goal of the exercise is met. However, we might agree that “standard tasks” rarely are performed in the real world as they are in a classroom setting. Significant differences exist that affect the manner in which the activities are performed.

This paper will present the “Talking Engine Room", a system used at the California Maritime Academy to fill the above void between detailed simulation systems and the real-world physical perspective. This interactive instructor-student query technique has shown that markedly increased student situational awareness can result in corresponding increases in actual knowledge, as well as in more valid assessment of each student’s true ability. Students must prove their actions verbally, not just “push buttons”. Potentially major error is thus reduced.

Keywords: *Assessment, Simulation, Interactive, Full-immersion, STCW, realism*

1. INTRODUCTION

The nagging question that often plagues an instructor in any technical course is: “Does Student X truly understand the material and/or procedures and systems necessary for successful completion and competency in the field?” We ask ourselves whether or not the student can adapt his or her learning to the real world, where decisions truly matter, or if not, what tools can we use to make sure that they can? For if we cannot find an answer to this dilemma and the graduate is subsequently fired from the job or involved in an accident, the instructor and institution come under extreme scrutiny of the community and regulators at large.

Within the myriad disciplines of traditional academics, for example Physics, Statics, History, Calculus, Political Science, etc., individual testing methods, essays, theses, and so on, are usually quite acceptable in gauging the student’s abilities. But when faced with actually proving that a candidate truly knows what do to in highly specialized fields requiring certification by government or international bodies, an instructor is often left wondering what a particular student truly knows. Time constraints force us to form a broader opinion on a group of students in a lab, all at the same time, rather than trudging through each and every one of them individually.

In the field of medicine, matriculates usually work with various laboratory tools, test equipment, “dummies” and cadavers under the watchful eyes of their instructors. Only after rigorous observation in these safe environments is a potential medical student allowed anywhere near a live person. In our own highly specialized field of Marine Engineering training, various simulators often fill a similar task to that of the “dummy”. However, the very nature of the exercises used to test a student’s abilities and responses in difficult situations often also means that they are working in tandem with multiple other students in a simulation group - again leaving us with the questions: “Can Student X do that alone?”; “Did he get it, or did someone else figure it out for him….?” In order for an exercise to be truly cross-compatible with a shipboard environment, group size must reflect that found in that environment. Otherwise, the training mission is lost; it becomes incongruent with the real world, essentially calling into question the validity of the exercise platform.

This assessment protocol is further compounded in the Marine Simulation field by the hard fact that even modern simulator systems still suffer two acute weaknesses: they cannot fully replicate every environmental aspect of the engine room (size of the ship, hot components, etc); and they do not provide all of the diagnostic tools available to an Engineer in the plant (such as the ability to listen to a pump directly or to feel a casing for odd vibrations). Response to casualties and diagnosis of malfunctions in a ship propulsion plant almost always requires quick assessment of the situation at hand, followed by rapid decisions on actions to be taken (or not to be taken, as the case may be). In today’s modern propulsion and steam power generation plant world, fully automated systems are relied upon to control virtually everything. And yet, to date, few if any propulsion simulator systems allow for an instructor to fail particular field devices - the very devices upon which the computer systems rely to manipulate the plant's systems effectively. What's more, students cannot utilize their various senses to determine things a shipboard engineer would "catch" immediately - such as the smell of an overheating motor.

Most difficult of all, none of the simulators on the market provide a truly life-like representation of the element of time. Valves open instantly (and almost always without fault; all one does is "click" on it); you can jump almost instantly from one system to the next, even though they span the entire engine room or ship; repairs are merely a click away via the removal of a fault malfunction. All of these time-related short-comings render much of simulation training quite unrealistic, the veritable opposite case to what we are all trying to do with these expensive machines.

It is the viewpoint of this paper that, while challenges most certainly do remain, the CMA has found an effective way of replacing these missing elements of student engineer diagnostics and operations, while at the same time providing the instructor (and student) with a far greater picture of an individual student's actual knowledge. Through forcing the watch personnel to describe in words their methods, ideas and actions, each student learns more -- and thus cannot escape the scrutiny of assessment. Realism of the scenario is therefore enhanced along with an end-of-the-day tally of the participants' true knowledge.

2. THE USE OF ENGINE SIMULATION AT CAL MARITIME

2.1 A bit of history of the simulation program

When the use of computerized simulators began at Cal Maritime back in 1981, terms such as "full mission" and "part-task training" did not exist; personal desktop computers did not exist. Simulators at that time, of course, consisted strictly of consoles driven by large main-frame computers. The school's original use of such systems stemmed from the need to provide students with an acceptable platform on which cadets could learn a slow speed diesel propulsion plant. As such, groups of students conducted various exercises toward bringing the plant fully online, largely through instructor-lead exercises that showcased the simulator's ability to insert malfunctions.

This sort of approach to the equipment resulted in the inevitable use of the system to "break things" without actual harm to a real plant. As no physical plant components were included with the facility, an assortment of console boxes provided the only means of accessing the various systems, valves and other devices one would find in the real world. Consequently, two primary problems arose: students had no real world space sense of what they would find aboard a ship; and the simulator itself was often turned into a game of "let's break this device and see what happens". Given that the exercises were conducted with groups of eight to ten students, all in a very small space (roughly eight by ten meters), no true assessment of individual students' knowledge was possible. All technical comprehension was gauged in the tangent lecture classroom exams.

As the mid-90s came round, so too did strict demand for assessment of every student's ability. By 1995, CMA now had an actual diesel training ship. In this new climate, however, the use of the diesel simulator strictly as a tool to drill cadets in casualty response grew even worse. Still there was no true physical size of the plant to contend with, or any of the other environmental aspects of a real ship. Exercises amounted to little more than the group learning to memorize a series of steps to accomplish a particular state of plant readiness. Unless the instructor took active steps to query each and every student as to why actions were taken, it was (and remains) all too easy for those with weaker comprehension to get through the course merely by being in the class with "smarter" students.

Further complicating matters of assessment was the United States' becoming a member of the Standards of Training, Certification and Watch-keeping (STCW) of 1995. This did force CMA to develop a more robust system of tracking each student's progress, but the same approach to the diesel simulator remained one of malfunction response. Most of the assessment of students' abilities was moved to the two training cruises all Engineers were required to take. But again, high levels of student-instructor interaction are necessary in order to ensure actual ability. Given the increase in student population during this same time frame, the school was also faced with the need for many more instructors than in previous years. Not all of these were quite as involved in student progress as they could have been, which resulted in an assortment of students with a wide range of actual knowledge.

The conversion of the diesel training program at this time to a combination of the training ship and simulators also left the Academy with void: how to maintain the steam propulsion training program. The answer became "let's get a simulator". But the newly acquired (ostensibly donated) facility turned out to be far unlike any such system anyone at CMA had ever seen - and with it, a complete underestimation of how to use it to its full advantage. The original Steam Plant Simulator included a full mock-up of an engine room for a fully automated tanker propulsion plant that provided students with some semblance of the real equipment they would encounter. But the scenarios at this time were still limited to response to malfunctions - and only at full sea speed, since that was the only initial condition available. In hindsight, however, this very system proved to be the catalyst for what has become a multi-level, inter-disciplinary program of marine engineering training. Much of the impetus for these major changes was the direct result of the Academy's work with various shipping companies, who themselves saw the need for the very type of team management and crisis response training that our unique steam simulator offered.

Through these cooperative ventures, many lessons have been learned as to the strengths, weaknesses and inherent problems encountered with today's high-spec marine simulators, particularly in regard to the ways in which they are used to produce an engineer with knowledge and experience that can be transferred to actual shipboard operations. Chief among these is the cold fact that no simulator can provide student engineers with all of the physical environment and field parameters one would have on a real ship. All subsequent simulation systems at Cal Maritime have been developed and training implemented with mitigating this concept in mind.

2.2 The Simulators Today: Adopting a Coordinated Approach

With the approach of the 21st Century came the realization that the Academy's simulators were in need of significant update. The existing full-mission diesel simulator had been online since 1981 and was no beyond further improvement. The full-mission steam simulator had been designed in 1978, relocated to CMA in 1996, and was completely obsolete electronically. Both systems have subsequently been replaced with modern, state-of-the-art systems - the diesel simulator in 2003; the steam plant in 1999 - and have been consistently updated periodically ever since.

The primary design criteria for both systems centred on three main areas: extensive fidelity for main and auxiliary plant system modelling; a broad range of associated plant subsystems; and (most vital to individual assessment) a set of computer based part-task trainer stations on which each student could conduct exercises with automated assessment. Both steam and diesel plant simulation training now utilize the full spectrum of these systems. Every student is required to perform individually on the PTT, and in a team setting using the full-mission simulators. The facility layout for each of these latter systems is specifically arranged so as to force students to move around to various terminals, consoles and spaces in order to perform tasks, rather than allowing all actions to be done on a central terminal.

Figure 1 Mock Steam Plant (partial)

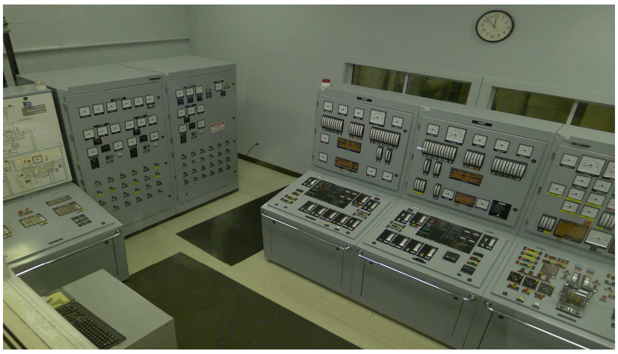

Figure 2 Engine Control Room

The Steam Plant Simulator depicted in Figures 1 and 2 is the focus of the pedagogical system described herein.

In addition to courses for undergraduate students, however, the Academy has also worked very closely with industry clients for various Engine Room Resource and Crisis Management courses. Indeed, it has been through these programs where the shortcomings of condensed full-mission simulators have been most problematic. But at the same time, it was through these same courses that other shortcomings have come to light. The solutions to these problems have resulted in marked improvement in engagement and focus: the students no longer "play a video game", but rather are now seen conducting themselves as actual Engineers.

2.3 The difficulties encountered: What was missing?

Despite the robust, complex and thorough modelling of the propulsion plants themselves, the simulators still cannot replicate key factors encountered in all marine engineering activities:

- The sheer size of the ship
- The noise of equipment when malfunctioning
- The distraction of crew and other people
- The distractions of unforeseen malfunction
- Uncoordinated operations of equipment
- Uncoordinated operations between departments
- Time needed for repairs or to transit the vessel
- Explosions, boiler panting, injuries, etc.
- Arc flash and other electrical sparking
- Disparate readings between gauges
- Poor communication and information relay
- Leaking pipes, vibrating pieces
- Actual personnel hierarchy and experience
- Situations occurring unrealistically
- Notable lack of a sense of urgency

All of the above issues have been cited by many of our industry clients as major detractions from the realism of all simulator classes. If the education we are trying to provide to our students is intended to be immediately cross-compatible with job site responsibilities, then striving for realism in all scenarios should be a primary focus. The manifestation of shipboard realism within a pair of 40-by-30 foot rooms, however, is very difficult to achieve. When six to eight students, each at the same academic level, are all vying to prove their abilities concurrently, all on the same task, the gap between real and simulated widens again. In fact, very often students will expect the instructor to step in to "fix" a problem or to reset the scenario after a major error. We all know, of course, that shipboard crews must be far more prepared for all operational requirements and infinitely more cognisant of the potential disaster that could arise.

Ironically, the most glaring manifestation of unrealistic situational response has come in the form student watch-standing aboard the *Training Ship Golden Bear* ("TSGB"), the very venue in which they are expected to function as industry-ready professionals. While aboard a typical merchant vessel a watch might consist of perhaps two individuals (one of whom is licensed), a standard four-hour watch aboard TSGB is comprised of three First Class Engineers (Seniors) and seven Third Class entry-level engineers. The former are tasked with running and organizing all operational aspects of the watch - under the supervision of the actual Licensed Watch Engineer ("LWE") - ostensibly functioning as the ship's "licensed" engineering staff, while the Third Class are responsible for taking data rounds of the plant, conducting routine clean-up and other general activities associated with a supporting member's role. These staffing numbers are far from realistic by almost any measure in the commercial shipping world. The First Class must be kept under close scrutiny to ensure that they remain apprised of the plant's status and their duties, rather than rely wholly upon their Underclass Oilers (themselves completely inexperienced as yet) to notice abnormalities and other operational conditions that could potentially affect the watch.

Further exacerbating this watch-standing disparity is the fact that all repairs and maintenance aboard the training ship are done by an entirely different group of Engineering students, the "Dayworkers", comprised of an entire division of cadets (thirty to forty students). As a result, two separate groups must coordinate their activities on a day-to-day basis, whereas on an actual ship, the same eight or ten engineers do basically everything. Morning briefings are held amongst these sailing crews to ensure coordination; no such meetings take place on the training ship, except amongst the officers in charge of day work.

The irony of the staffing situation on the training cruise is best observed by the students themselves - all of whom would have just returned from a commercial cruise the previous summer. Without exception, the First Class recognize that the numbers aboard the TSGB simply do not equate to real world conditions in the least. Most have become frustrated with the number of people on watch and the often disconnected activity of day work and vessel operations. All planning around these factors is, in fact, still of necessity done by the vessel's actual engineering staff, with students serving in a role ranging from observational to mid-level oversight. These very First Class students have pointed out that *all* of their simulator courses are completed by the time they sail aboard the Golden Bear again in an operational role.

It would seem, then, that we have had it backwards in some regards. If the primary point of simulation training is to prepare our students for jobs at sea in the maritime industry, equipped with the essential organizational, technical and leadership skills they need for success, it stands to reason that more realistic use of the simulator classes simply had to be implemented. All operational aspects of the ship should be taken into consideration while decisions are being made; all contingencies to accomplishing daily tasks must be incorporated into scenarios. Simply assigning the students a particular task for that class session - for example, placing a generator online - is wholly unrealistic when that is the only thing they're expected to think about. That is not how a real ship operates, so why should the simulator? Elementary systems familiarization is quite effectively accomplished on part-task simulators, in a safe setting. Learning how to do things when an actual vessel could be in jeopardy is not acceptable, yet the levels of stress associated with that jeopardy could well provide the impetus for deeper learning. The pressure to know your job *before* disaster is at hand is often lost on a student standing in front of a computer terminal in a simulator, where no actual damage can occur - and perhaps provocatively, no penalty will be incurred for that damage, potentially leading to further disassociation between real and simulated. While the Academy has experienced excellent success using PTT simulators for essential systems training and assessment of individual students (particularly with regard to heavily documented STCW competencies), we have found that team training requires a very different approach if said deeper, high-level cognizance is to be achieved in the long term.

2.4 The Human Factor in Simulator Pedagogy

The most critical problem facing the Engineering Technology Department at Cal Maritime has proven to be the inherent inconsistency brought about the sheer variety of instructors needed to cover all of the simulator courses. Between roughly 2000 - 2008, up to twelve different instructors were concurrently teaching the three simulation courses in the curriculum. While each instructor's methods and style certainly have merit on their own account, this very diversity of instruction had become the single biggest obstacle to ensuring consistency of student STCW assessment and validation of graduates' actual technical ability. For some time, in fact, only two of the Department's instructors were actually members of the Faculty; all of the rest were temporary adjuncts hired on a per-semester basis or, in some other manner, transient at best.

During the middle of this same time frame, significant changes had also been made to the Marine Engineering Licensing curriculum. The full impact of these major changes is beyond the scope of this paper, but it nevertheless was the catalyst for developing the new pedagogical method discussed herein. Tangentially, the two-cruise system CMA had been using since 2000 also had an effect. The ET Department simply did not have enough personnel to cover both training cruises, thus several more adjunct faculty were needed. The result was still more inconsistency. At the end of the day, however, it was the California Maritime Academy whose name would be attached to the qualifications of every student upon graduation.

Clearly, then, some sort of filter was required to "catch" weaknesses in a student's knowledge level. As is so often the root cause behind the majority of marine casualties and accidents, so too have all of the difficulties above conspired to create a significant problem in guaranteeing that each and every student had met the school's requirements. No one problem was to blame; as always, it was the combination of these challenges that led to thoughts of a new approach.

In the end, however, the most painful problem encountered has been the fact that students often had little idea how their scenario grade was derived. Other than written exams, little quantitative information was provided to them regarding how the exercise went - other than whether or not they achieved a certain STCW competency. Even this was unrealistic, however, when students are simply lined up and tasked with performing the required steps. As a result, many students have left the classes with a sense of nebulous learning and dissatisfaction.

Conversely, of course, the instructor has often been left with the quandary of figuring out just how much a specific student knows versus how much benefit he or she derived from others' knowledge. This, in fact, was the crucial reason a solution had to be found.

3. THE "TALKING ENGINE ROOM" SYSTEM

None of the above would seem revelatory to anyone involved with the use of advanced marine simulators today. However, during any variety of such courses, perhaps instructors would agree that the single most frustrating attitude encountered with students working with such systems is the idea summed up by Undergraduates' statements such as these:

- "Ah, I'm just going to play with the sim for a couple of hours".
-"I'm not busy; I'll just be in the simulator".
Or in a debriefing, perhaps one has heard….
-"It's nothing but a video game, so why does it matter?"
-"It's only just a computer; nothing bad can happen"
-"Let's see if we can blow it up. That would be fun!"
-"Mr. X, can we see if we can make the ship sink?"
-"Ms. Q, my computer is acting slow/weird. How am I supposed to do the test?"
-"The light came on, so it's running"
-[looking at a PC screen] "It's got pressure, so everything's OK"
Or after a major error - usually brought on by poor or unconcerned forethought:
-"Mr. Y, can we start again?"
-"So what? It's not a real ship"
-"Well, it was unfair because we were missing one of our [eight watch-stander] guys. You ought to cut us some slack"

Even professional Marine Engineers, often brought to full-mission simulation facilities for Engine Room Resource Management training or other advanced courses, are very easily "lost" on the first day because they simply discount the realism of the facility's setting. Perhaps instructors for such courses can relate to comments such as:

-"That's stupid, I would have known about the 'standby engines' time hours ago"
-"Yeah, maybe that could happen, but what about the noise I would have heard beforehand?"
-"Yeah, right! Do you know how many motor-operated valves have frozen up on me just this year?"
-"Well, it's just the simulator, so we don't have to [take a certain precaution]"
-"There's no way that would have happened! We would have seen the leak by just standing there by the pump!"
-"There's no way I can do that. We don't have the money for it, or the Office would scream".

These are just some of the many comments the author has heard from students over the years. Significantly, the comments and feedback received from industry clients have had the most impact on addressing not only Continuing Education courses, but more profoundly on those heard from undergraduates at Cal Maritime. Indeed, it was realized that the quickest way to quell such dismissive comments from the budding engineers was to eliminate all vestiges of artificiality - as much as feasibly possible - in the simulator.

Using the Full-Mission Steam Plant Simulator for EPO235 Watch Team Management as the starting point, students no longer were to receive orders on a given day to conduct a particular exercise. Rather, they are now faced with operating an actual "ship" according to the mandated vessel's sailing orders. Imbedded within the orders are the "Milestone Dates" that prescribe the date on which major plant status conditions must be achieved. Each Watch Team group receives a different set of orders. When a group meets a deadline, maximum points are awarded. Should they fall behind schedule - correlating to a potential delay in the ship's schedule - progressively higher point penalties are assessed. Consequently, the group that learns to organize and to conduct business diligently, thus being ahead of schedule, is awarded bonus points. Again, anything that happens during a given class session carries over to the following week as the initial condition.

These simple changes were the logical extension to addressing another common fault experienced with undergraduate simulator courses: students felt they were being held accountable to no one but the instructor; their actions could be taken with impunity, regardless of potential real-world consequences. Resolving this issue has been explored successfully using the "Vessel Masters Program" begun in 2009 [1]. By extension, Engineering cadets are now required to take the entire engine room and vessel - including all personnel, whether physically present or not - into account while performing all tasks. All tasks now reflect the timeline history of that section's ship.

3.1 Orchestration of the Watch: The Whole Ship

The key components to what has now become known as the "Talking Engine Room" system have, by virtually all student accounts, brought a heretofore unheard of sense of realism to the advanced levels of simulation training. The implementation (at least initially) was simple: rather than issue a set of instructions for the simulator class day, each class section receives a set of sailing orders for the entire semester. In order to accomplish these orders, students must access every part and person necessary to operate the ship, thus concurrently achieving all related STCW competencies associated with EPO235. These weekly activities thus require the student Watch Team to see things, to do things, to hear things, to work on things are simply not included or possible with the simulators. Such activities range from:

-Local control to start equipment first, then switch to automatic remote;

-Conducting visual and auditory rounds of equipment while operating;

-Visiting other officers, workers and crew not present in the Control Room;

-Verification of actual valve position vs. indicated;

-Performing repair and maintenance tasks outside of the Control Room;

-Being in spaces in the ship not included in the actual simulator facility (e.g. Bridge, Cargo Control Room, pier)

-Repair and diagnostic efforts on equipment in the plant;

-Blow-down of the Auxiliary Diesel Generator;

-Emergency manual operation of equipment.

In essence, anything that the engineer would need to observe or to perform that is not explicitly included on one of the consoles or in the mock Engine Room Spaces, he or she must come up to the Instructor Operating Room (IOS) to describe the action to the instructor or to pose specific questions regarding equipment. This means that the instructor, by extension, can query the student as to why they wanted to do that, or why they ask that question. We can verify the thought process the student is using to analyze a certain problem and offer socratic suggestions to help them through understanding the situation at hand.

Initially, the idea for this tactic was brought about by two general observations in class: the aforementioned difficulties in providing realism; and having witnessed various student engineers perform actions that could easily have caused major physical harm in a real setting. It was evident that a "virtual" engine room was needed; something that could supply the needed missing components of the plant and ship. Somewhat entertainingly, it was the students themselves who devised the now-standard term for these virtual spaces, the "Talking Engine Room (TER)".

The concepts of recognizing a realistic time to do things and that all actions come with consequences have thus been largely mitigated simply by forcing the students to leave the Control Room and explain themselves. The instructor can force the student to stay upstairs, detached from the group, for an indefinite amount of time, somewhat replicating that needed in the real world (within reason). In addition, he can also witness benignly a myriad range of errors his or her own teammates are committing, simply by watching from above. This has helped to reduce the "tunnel vision" so common to marine engineers stuck in a control room on one task.

However, perhaps the most vital aspect of this new protocol - and one that represents the single biggest improvement in realism - is that the results of all actions the students take in the "engine plant" remain with them for the duration of the semester. This means that inadequate attention that results in a failed pump, for example, is their "history": the pump is out of commission, potentially affecting whether or not the vessel can meet its deadlines. When damage resulting directly from student actions requires repairs, money is taken from the group's nominal operating budget. The amount of money they have left at the end of the semester is a significant portion of the groups' overall grade, thus we have found that most groups make great effort to think before they act.

This "payback" effect upon Watch Team performance also includes the aforementioned Vessel Masters Program, whereby faculty of the Academy's Marine Transportation Department (MT) have graciously offered their consultation services to Engineers. Whenever a significant event occurs as a result of the Watch Team's decision-making process - for example, delay in departure time; injury to personnel; serious damage to primary equipment - the Chief Engineer and other watch-standers involved in the incident are require to meet with their assigned faculty "Captain". As most of the Engineering students are not well acquainted with MT faculty, this mandate has forced them to recognize that they are definitely not functioning as stand-alone crew; they are part of an extremely dangerous and expensive operation. It has also been shown to foster far greater integration and familiarity of Engineering cadets with the Deck. Throughout the history of CMA, Engineers have virtually zero contact with faculty in the MT Department, thus this program, as an extension of the Talking Engine Room, has served to provide more realistic decision-making. Many students have commented that "the last thing they want to have to do is talk to some [person] they barely know and explain their stupidity".

In forcing students in the Watch Team to recognize the roles other crew members play in vessel's operation and that they must take into account all aspects of the Engine Room (not just the ones they can "click" on), the structure of the watch has become more fluid and realistic. Decisions on what to do are no longer purely dependent on what the assignment for that day is; they are made based on the ramifications on their ship overall.

3.2 Orchestration of the Watch: Personnel and Spaces

Throughout almost the entire history of simulation training at CMA, students in each of the class sections have been assigned specific titles primarily for purpose of keeping them focused on very specific tasks. While some overlap of tasks did take place, the integration of STCW Competencies resulted in these assignments being further restricted to a very specific task at hand. Table 1 describes the general assignment system previously used for most simulation exercises:

Table 1. Standard Student Watch Positions

Crew Position	Primary Responsibility
First Assistant (1)	Watch Engineer
Second Assistant (1)	Boilers and Steam Generation
Third Assistant (1)	Electrical Plant and Auxiliaries
Non-licensed Ratings (1-3)	Assistance as directed

The student demonstrating an ability to control boiler water level therefore was, by definition, specifically the Second Assistant Engineer. Any industry engineer knows, however, that the watch would never include the entire Engine Department, nor would only one person be allowed to manage water level: everyone on a modern-day watch would be keeping an eye on this critical parameter. Again, the previous system often detracts from realistic immersion training in the simulator.

The TER system, however, by virtue of requiring personnel to leave the Control Room (or even the Engine Room entirely), forces the student Watch Team to function in more realistic fashion. Consequently, enhancements have demonstrated in:

-Greater attention to managing personnel and their whereabouts;
-More refined and careful communications amongst people in and out of the plant;
-More flexible arrangement of actual tasks;
-Greater impact of distractions upon focus;
-Greater attention to the hierarchy of decision-making;
-More careful planning of each day's activity;
-Better pre-planning and practice before class;

In effect, all six students no longer perform as a large Watch Team, but rather as an Engineering Department. Only a couple of them are on the actual "watch" at any given time or in the Control Room. Inspiration for this arrangement was the direct result of work CMA has done with shipping companies, all of whom have commented that the number of people at hand in the Control Room previously was unrealistic and incompatible with true decision-making. Similarly, one member of the class section is now appointed as the "Chief Engineer", upon whose shoulders the overall organization of the entire activity toward achieving the Milestones rests. In all previous simulation classes, the Instructor has served as the Chief, the Captain and all other people on the ship, thus providing the student with a "safety net" who would step in with key information or directions. Essentially, this was little different from arrangements on the training cruises, where students take absolutely no part in planning or decision making. If the product of the program is intended to be a graduate who is accustomed to such planning and decision-making, then the author would argue that they must be allowed - indeed forced - to take part in these aspects of vessel operation at some point in their matriculation.

This new protocol system has placed far more stress upon the student assigned to the Chief Engineer position, but all students thus far have remarked that "this forced [them] to be ready and to be on [their] toes".

4. FINDINGS AND FEEDBACK

Undeniably, the TER program does require intense concentration and engagement of the instructor involved. The stress levels amongst the Watch Team members forces them to pay attention to all of their actions and to utilize all information at their disposal - especially that obtainable only in the TER - but so too do they require extremely well organized and thought-out scenarios. But because class sessions are no longer dedicated merely to specific tasks for the day, just about anything can happen. Students have quite often changed the entire course of the proposed day's plan simply by hitting the wrong button or by turning off the wrong burner in a boiler, for example. However, this very possibility is exactly what forces the Team to be "on its toes".

Students have reported that this "Unknown" leaves them with no choice but to learn about the systems, components, operations and watch management techniques that define the course content. More than a few Watch Teams have described this as the "Randomness Factor" that causes each and every session to feature unexpected events that force them to double check equipment, to be extra careful in placing systems on line, and to be more diligent on rounds of equipment they cannot "see" nor monitor on the physical consoles. Indeed, it has also enlightened them as to the inevitable potential unreliability of electronic transmitters and computer networks: all professional mariner engineers are well familiar with inaccuracies of tank level indicators, vibrating pressure gauges, and other erroneous or suspect instrumentation. Although the automated assessment monitoring systems most modern simulators employ can help with tracking common errors and general operations, they simply cannot realistically be programmed to respond to all possible situations or outcomes; they cannot adapt to changing scenarios. Once the scenario has veered from the pre-determined path, the assessment system is usually rendered inaccurate.

Nevertheless, these very observations also indicate that the system requires that *all* students be up to task. What's more, they have realized that must become at least familiar with the general responsibilities outlined in Table 1, for at any time, a student may be absent from class or be taken "out of the action" through being delayed in the Talking Engine Room. They *must* know their jobs each and every day, for to fail invariably leads to the suffering of the entire team - usually in the form of a significant delay in reaching a Milestone.

4.1 Unforeseen benefits

At its early stages in the Fall of 2010, each Watch Team was given a similar set of Sailing Orders. This was done in order to keep each section of class on roughly the same schedule. As a result, during the first several weeks of the semester, most "ships" were at quite similar points in bringing the full plant online. While some sharing of experiences amongst the various students could be seen as beneficial, it all caused a bit of predictability as weeks went on.

The latest iterations of the TER System have instead begun each class with a totally different set of Sailing Orders and initial conditions. No longer can each class contaminate others by reporting what they did, for every ship is completely different. Coupled with the inherent uncertainty of actions described above, this heightened unpredictability has actually increased student satisfaction with their learning experience. All classes, all students must each face their own challenges. While some similarities do eventually arise, they are now always within a totally different context or situation, forcing the Watch Team to be more proactive in being prepared.

As each crew member position rotates on a two-week cycle, the students have also discovered that “being stuck upstairs” (in the TER) is actually not a penalty, as they’d originally thought it might be. Instead, they have learned the value of being able to observe actions, communication errors, breakdowns in command structure and a host of other human factor issues that they otherwise would not have noticed had they been “stuck” in the Control Room or Engine Room instead. In actual practice, in fact, many have experienced simulated injury and death as a result of Control Room personnel operating equipment remotely, having forgotten that some person at the TER had been sent to the same machine locally (i.e in the TER). Previously, students routinely would operate machinery on a Control Room terminal or console in complete oblivion to the fact that someone might actually be in danger at the actual machine. This level of precaution is common practice on real ships; completely ignored in most simulation exercises.

The students and instructors in the Watch Team Management course occasionally have ostensibly disparate missions. Instructors must be certain that the engineer candidate meets international, federal and institution levels of competence. Most students want this too; they want to learn about being an “Engineer”. But a few are content simply to “get by” with the bare minimum of knowledge to get through the curriculum as quickly as possible, with a sharp eye toward graduation. With the Talking Engine Room mandates of routine rounds, explanation of actions and theory, and situational awareness in the broad context of an entire ship, however, students now realize that they cannot simply get by just by being in class and relying on the wisdom and diligence of others. At any given time, they now *know* that they, in fact, will be called upon to prove their ability.

4.2 Student response: the true indicator

Universally, the majority of students have commented that the TER System has helped to prepare them more effectively for situations they might encounter in the real world. The fact that their duties aboard ship will never be conducted within the sanitized conditions of a traditional simulator exercise is not lost on them. Some sample comments received from various students might sum up the overall response to this new approach:

“The [TER] helped the students have a better understanding of running a steam plant by assisting us to (sic) have a deeper thought process of why and how equipment functions”.

“The class felt more as being in an actual ship than just a class and clicking on a computer screen.”

“[It] helped the students to think outside the box and how to troubleshoot a problem with simple questions that lead to the final answer.”

“The [TER] helps to transform the class from running a simulator to running a steam plant.”

“There could be a strange smell, smoke… frayed wires that a simulator or computer screen won’t tell you.”

“It … enhances the real world time factor that would affect people in the plant. For example, on a real ship it takes 10 minutes to walk up to the EDG, but in the simulator it’s right there.”

“Having people out of the Control Room provides a more realistic environment with respect to crisis management.”

“I feel that I was well prepared for most alarming situations I experienced in the Engine Room this [training] cruise.”

All of these comments would seem to show that the students, for whom we in the education field work, have been well pleased with the improvements seemingly indicated through the use of the Talking Engine Room System.

5. CONCLUSIONS

In the end, this new protocol has given instructors a far more accurate picture of each student’s knowledge. It does require extreme levels of attention on his or her part, but the confidence gained in student progress arguably makes the effort beneficial in the long term.

Since the program began, all class sections have shown marked improvement in preparation, communications, planning, crisis response and - most importantly - far fewer incidences of major casualties to the plant. In Fall 2009, all sections of EPO235 experienced in some form significant plant error that required a visit to the Vessel Master assigned from the MT Department. As of Spring 2013, only two such cases occurred. Tangentially, this improvement could be related to the concurrent increase in student use of after-hours practice sessions: approximately 65% of students utilized practice time in 2009; in 2013, 92%. More exact metrics for tracking specific changes are under development at this stage.

6. ACKNOWLEDGMENTS

This paper could not have been accomplished without the steadfast enthusiasm, dedicated professional input and unwavering support of the Marine Engineering Technology and Licensed Mechanical Engineering students of the California Maritime Academy. In particular, the author would like to express deep appreciation to following students for their comments and input, specifically: Matthew Hysell, Kyle Vanderspek, Eric Johnson, Joshua Keller, Matthew Steffy, Glenn Fuller, Jesse Skeets, Richard “Ricky” Ocon, Jeffrey Squier, Adam Farnsworth, Owen Hurley, Emily Dackins, Russell Penniman, and countless other dedicated students. In addition, the feedback and contributions of the engineering staff and crews of Polar Tankers (formerly ARCO Marine), Exxon-Mobil SeaRiver Shipping, and Chevron Shipping have been instrumental in developing this program.

7. REFERENCES

[1] GREEN, S., SCHMID, W., *Maritime Education Summit*, Massachusetts Maritime Academy, 2009.