Experiential Learning for Marine Engineering Technology Students Aboard Ship

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Abstract

Maine Maritime Academy (MMA), located in Castine, Maine, is known for its hands-on experiential training–none more real life than the time students spend on the Training Ship State of Maine (TSSOM). Students embark on two cruises on this 500-foot diesel or electric motor-propelled ship during their academic course work at MMA, where they spend several weeks applying the knowledge obtained in classrooms on campus to an operating plant, a virtual "city at sea." These students operate, maintain, troubleshoot, and repair complex propulsion, electrical, and support systems while being supervised and mentored by experienced licensed marine engineering officers. MMA faculty members, many of whom have extensive industrial experience, participate in the training cruises to provide education in the ship's classrooms and oversee this experiential learning process. The cruise curriculum is both challenging and immersing and provides context to the students about potential career opportunities and challenges while preparing them to progress on their chosen academic path.

While there are several engineering-track options available at MMA, one of the most popular on campus is the Marine Engineering Technology (MET) major, an ABET-accredited, United States Coast Guard (USCG) program-approved course of study that incorporates extensive hands-on learning in small groups to reinforce theory. Graduates of this rigorous program earn both an ABET-accredited engineering technology degree as well as a USCG unlimited horsepower third assistant engineer license. This prepares them to pursue careers at sea in the merchant marine or to pursue a wide range of career opportunities ashore.

History of Maine Maritime Academy's Marine Engineering Technology Program

MMA was created to provide nautical training by an act of the 90th Maine Legislature on March 21, 1941. MMA first offered two-year programs to meet the nation's needs for merchant mariners during the Second World War. The programs were later extended, and MMA was offering 4-year Bachelor of Science degrees by 1960 [1].

MMA's Marine Engineering Technology (MET) program, started in 1985, is one of six engineering, engineering technology, and engineering operations programs currently offered by the college. The program has been accredited by ABET since 1986, and approximately 180 of MMA's 1,000 full-time undergraduate students are enrolled in the program.

Students in MMA's MET program not only complete all coursework required by ABET but must also complete all United States Coast Guard (USCG) requirements for unlimited horsepower third assistant engineer officer licensing [2]. The MET students participate in extensive hands-on learning in numerous shoreside laboratories, but much of the experiential learning required to develop students into competent officers in a ship's engine department is completed on the Training Ship State of Maine (TSSOM), shown in Fig. 1 on the next page. Various ships have supported student learning at MMA since the beginning: the current TSSOM is a former U.S. Naval Ship, now owned by the US Maritime Administration and operated by MMA since 1997. It is approximately 500 feet long, displaces over 16,000 tons, and is propelled by an 8,000-horsepower diesel engine [3].

Students in the MET program are required to cruise on the ship in the summers after their freshman and junior years. Faculty in MMA's Engineering Department, many of whom hold USCG-issued engine officer licenses, develop and implement the curriculum on these summer training cruises. Students participate in traditional classroom discussions during cruises, but this learning is reinforced by a diverse array of hands-on labs in the ship's machinery rooms. Students are also required to conduct shift work (known as "watchstanding") in the engine room, and help operate, maintain, and repair the ship's machinery.

Fig. 1. TSSOM in Cadiz, Spain, in 2019.

MMA MET students must successfully complete all USCG licensing requirements, including passing a comprehensive multi-day examination, in addition to all other academic work. Many graduates initially pursue careers at sea, but opportunities abound ashore as well. The MET program's numerous hands-on labs, afloat and ashore, reinforce traditional coursework and develop versatile engineering technologists.

Education at Sea

All MET students are required to complete three distinct educational experiences at sea. These summer experiences are designed to provide participants with robust hands-on activities that reinforce material covered in the classroom. All of these summer training cruises have significant embedded academic requirements and have course designations in the undergraduate catalog. MET students embark on the TSSOM immediately after their spring semester ends. During their Freshman Cruise (CE103), which lasts approximately 37 days, students will learn many basic lessons about life as a mariner. The experience they gain at sea, along with the additional classes taken in their second year in Castine, prepare them for their "cadet shipping" experience.

MET students serve with professional mariners for at least 60 days while participating in cadet shipping (CE203). MMA partners with numerous companies, and students are assigned "billets" aboard one of a wide variety of ship types. Some cruise on tankers or cargo ships, while others serve aboard civilian-crewed, but government-owned, vessels supporting the US military. Each cadet must successfully complete a detailed "sea project," an illustrated technical report covering many aspects of the ship's engineering equipment and systems.

The final sea term for MET students is Junior Cruise, CE303, taken during the summer after their junior year. This course typically lasts approximately 74 days, and serves as a capstone sea experience. CE303 students are expected to demonstrate advanced leadership and technical skills and mentor those participating in their first sea cruise. The next sections of the paper will focus on CE103 and CE303.

Freshman Cruise (CE103)

MMA's first year MET students study the same topics as those in other ABET-accredited engineering technology programs. However, they must also complete numerous additional requirements. The USCG requires license candidates at state maritime academies to participate in a "regiment" to prepare them for a career at sea. Students participate in a regimental training program prior to the start of their first academic year. They learn how to wear required uniforms, maintain physical fitness, and the basics of shipboard life. MET freshmen also take courses in ocean survival and firefighting, and study critical shipboard systems and safety requirements before they begin CE103.

CE103 students are divided into four "companies," and each company rotates through the following areas: training, watch, maintenance, and utility. Students in training attend classes and participate in a diverse array of faculty-led labs. Students assigned to watch stand two four-hour shifts in TSSOM's engine room. Since the ship's machinery operates 24 hours a day throughout cruise, watches are organized to allow mariners eight hours off between each shift. Individuals will stand watch from 8am to noon and 8pm to midnight, noon to 4pm and midnight to 4am, and 4am to 8am as well as 4pm to 8pm. Maintenance company assignments focus on both preventive and corrective maintenance (repairs). Finally, CE103 students complete a

diverse array of tasks while assigned to utility company, such as cleaning the ship's interior spaces, serving food, cleaning dishes, removing garbage, loading supplies, etc. MET CE103 students perform many of the duties typically accomplished by entry-level mariners on commercial ships, and obtain valuable first-hand knowledge regarding tasks they will supervise after graduation.

Seven engineering faculty members serve as training officers aboard cruise, and develop and deliver the CE103 and CE303 curriculum. Table 1 is a schedule of the eight training days for CE103 last summer. Each company had about 16-18 students. All students in a company would simultaneously receive traditional classroom lectures, but the company would be split into two or three smaller groups for hands-on labs.

Table 1. 2021 CE103 training schedule.

Day		Group 1	Group 2	Group 3	Lecturer	Time (hrs)	Checkoffs
1	AM	Cruise Training Introduction	Cruise Training Introduction	Cruise Training Introduction	S	0.5	N
	AM	Tools 01 Lounge	Drill & Tap	Tank Soundings	H/W+M/F+G	2	N
	PM	Tank Soundings	Tools 01 Lounge	Drill & Tap	F+G/H/W+M	2	N
2	AM	EngSystems Ovrvw (MEJW, MELO, M/ASW)	Eng Systems Ovrvw (CFW)	Watchkeeping Practices	M/G/H	1.5	N
		Eng Systems Ovrvw (CFW)	Watchkeeping Practices	EngSystems Ovrvw (MEJW, MELO, M/ASW)	G/H/M	1.5	N
	PM	Drill & Tap	Tank Soundings	Tools 01 Lounge	W+M/F+G/H	2	N
		Watchkeeping Practices	EngSystems Ovrvw (MEJW, MELO, M/ASW)	Eng Systems Ovrvw (CFW)	H/M/G	1.5	A3/1:3.1
3	AM	Linehandling	Linehandling	Linehandling	DTO	3	A3/1:4.10
	PM	Valve Maintenance		Electricity & Hands On	T+G/W	3	N
		Engine Room Safety for Deck Freshmen			M	1.5	N
4	AM	Confined Space Entry	Confined Space Entry	Confined Space Entry	DTO	3	N
	PM	System Tracing	System Tracing	System Tracing	F+G+H	3	N
5	AM	Electricity & Hands On		Valve Maintenance	W/T+G	3	N
	PM	Copper Piping Project & Cut Gasket		Occupational. Safety and Health	W+T/F+H	3	N
6	AM	STCW Assessments	STCW Assessments	STCW Assessments	3	3	N
	PM	Occupational. Safety and Health		Copper Piping Project & Cut Gasket	F+H/W+T	3	N
7	AM	Black Pipe Project		Environmental Awareness	W+M/F	2	N
				TroubleShooting	W+M/F	1	N
	PM	Environmental Awareness		Black Pipe Project	F/W+M	2	A6/1:4.2.3/A3/1.8.2,5, A3/5:7.1
		Troubleshooting			F/W+M	1	N
8	AM	NO AM Class - Prep for Assessments & Exam					
	PM	Engine Room Individual System Assessment	Engine Room Individual System Assessment	Engine Room Individual System Assessment	ALL Except S	3	N
	1600	Written Exam	Written Exam	Written Exam	All	3	N

The USCG requires students to demonstrate proficiency in a wide variety of skills to qualify for an engine officer's license, and faculty oversee development of and assess proficiency of these skills (called competencies) during cruise. Fig. 2 shows one of the small groups of CE103

students receiving a brief before starting a practical lab. Although students complete multiple practical and knowledge-based assessments throughout the cruise, their final training day consists of comprehensive assessments. As an example of how experiential learning reinforces lessons taught ashore, students learn about some of the ship's systems during their first year. These systems are discussed in class, and students are required to draw some of them before their first cruise. Faculty provide an overview of selected systems in classrooms during CE103, then students are divided into small groups before entering the ship's engine room to trace (follow piping to identify all components) systems assigned to them by faculty. Students then return to the classroom, where they draw and explain systems they traced. Faculty critique their drawings and correct errors and misunderstandings. Although each group of students only traces one system in class, they are expected to trace several others on their own time. During the last day of training, each student enters the engine room at a designated time, where they are assessed on their understanding of a randomly selected system by a faculty member. This multi-step process is designed to increase each student's knowledge and understanding of a variety of ship's systems to better prepare them for the next academic year and CE203.

Fig. 2. CE103 students preparing for a piping project lab.

Junior Cruise (CE303)

CE303 is the third and final course at sea for MMA's MET students, and is essentially a capstone for their experiences at sea. As with CE103, students are divided into four companies, and are often split into smaller groups for labs and other practical exercises. The training day schedule for summer 2021 is shown in Table 2 on the following page.

Modern ships have a wide variety of equipment and systems supporting vital functions such as propulsion, electrical generation, and habitability. Ship's engine department officers must be able to effectively operate, maintain, and repair these complex systems. MET students have completed much of their technical education when they embark on CE303, and they are expected to operate TSSOM. Although they are mentored and supervised by both faculty members and the ship's crew, they are expected to lead teams of peers and CE103 students throughout the training cruise. Fig. 3 shows a CE303 student receiving instructions from the ship's chief engineer before he takes control of the ship's main engine and propeller.

COVID-19 and Other Scheduling Challenges

The ongoing pandemic placed great stress on all colleges and universities, including MMA. No summer training cruises were held in 2020, and many students were unable to complete cadet shipping (CE203). The experience and knowledge students gain during CE203 is critical to their success in CE303, so scheduling summer courses was a significant challenge. The USCG reduced the number of sea days required for students graduating in 2021, so MMA decided to hold three training cruises in 2021. The first cruise lasted 37 days and included students who originally would have completed CE103 and CE303 in 2020. The upper class MET students,

Fig. 3. CE303 student preparing to control ship's main engine and propeller [3].

who had completed all graduation requirements except for CE303 and the USCG licensing exam, participated in a cruise 50% shorter than was originally planned. Consequently, the faculty training officers spent much time deciding what to include in the cruise (and verifying that all USCG requirements were met). Several labs had to be truncated or eliminated. Some activities had to be rescheduled because of unfavorable weather or heavy shipping traffic. Several labs were taught by MMA's Marine Transportation Department faculty, who primarily teach students preparing to serve in the deck departments of ships following graduation. Deck department officers are responsible for traditional seamanship tasks such as safely navigating ships, loading and discharging cargo, operating small boats, anchoring and linehandling (using ropes to hold ships securely to piers). Deck officers also usually lead firefighting and other damage control teams. Close coordination with the two groups of faculty trainers and the ship's officers was essential. Fig. 4 shows one of the many engine faculty planning meetings held on the first cruise in summer 2021, and Fig. 5 shows students, wearing required protective gear, practicing entering a confined space that didn't have adequate levels of oxygen.

Table 2. 2021 CE303 training schedule [3].

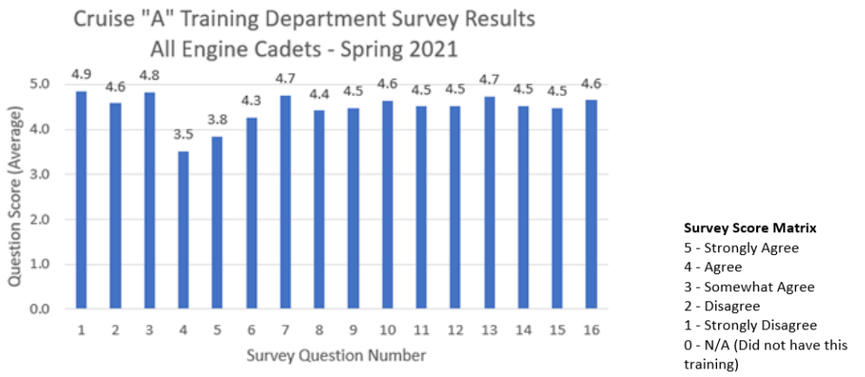
Day		Group A	Group B	Time (hrs)	Instructor(s)	Checkoffs
1	0800	In Port Training	In Port Training	1	All	N
	0900	Cruise Training Introduction	Cruise Training Introduction	0.5	All	N
	0930	Steering Gear Overview	#3AE Tasks - Steering Gear Tests	1.5	S/T	N
	1300	#3AE Tasks - Steering Gear Tests	Steering Gear Overview	1.5	T/S	A3/1:4.7
	1430	3 A/E Tasks - Control Clutch, Pitch, and MPDE Locally Overview	3 A/E Tasks - Control Clutch, Pitch, and MPDE Locally Overview	1	ST	N
2	0800	3 A/E Tasks - Operation of Watermakers	ERM	3	F/S	N
	1300	ERM	3 A/E Tasks - Operation of Watermakers	3	S/F	A3/1:1.7, A3/1:16.1,3,4,5
3	0800	3 A/E Tasks - Control Clutch, Pitch, and MPDE Locally While Underway	3 A/E Tasks - Control Clutch, Pitch, and MPDE Locally While Underway	2	ST	A3/1:4.1, A3/1:4.5
	1000	3 A/E Tasks - Safe Working Practices Part 1	3 A/E Tasks - Safe Working Practices Part 1	1.5	F	N
	1300	3 A/E Tasks - Respond to Loss of Steering - Steer Ship Locally While Underway	3 A/E Tasks - Respond to Loss of Steering - Steer Ship Locally While Underway	2	ST	N
	1500	3 A/E Tasks - Safe Working Practices Part 2	3 A/E Tasks - Safe Working Practices Part 2	1.5	F	A3/5:10.1-9
4	0800	3 A/E Tasks - Operation of MSD	Motor Controllers	1.5	T/W	N
	0930	Motor Controllers	3 A/E Tasks - Operation of MSD	1.5	W/T	N
	1245	Mentoring Time with 4/C	Mentoring Time with 4/C	0.15	All	N
	1300	3 A/E Tasks - Meter Usage	3 A/E Tasks - Basic Electrical Wiring	1.5	M/W	N
	1430	3 A/E Tasks - Basic Electrical Wiring	3 A/E Tasks - Meter Usage	1.5	W/M	A3/1.7.3, 5
5	0800	DC (w 2/C Deck Joining)	DC (w 2/C Deck Joining)	2	S	N
	1000	Environmental Awareness	Environmental Awareness	1	F	A3/1:10.1-3, A3/1:15.1, A3/1:16.2, A3/5.4.1, A3/5:9.1
	1000	Welding (for Deck 2/C)	Welding (for Deck 2/C)	1.5	H	N
	1300	Rigging	Rigging	1.5	G	A3/5:5.5.2,4
	1430	Ballast/Confined Space Entry	Ballast/Confined Space Entry	1.5	DTO	A3/5:4.1
6	0800	Engine Readings	Operation of Oil/Water Separators	1.5	SW/T	N
	0930	Operation of Oil/Water Separators	Engine Readings	1.5	T/SW	A3/1:5.4
	1300	Operation of Air Compressors	Pump Review Including Mech Seals	1	H/G	N
	1400	Pump Review Including Mech Seals	Operation of Air Compressors	1	G/H	N
	1500	High Voltage Awareness	High Voltage Awareness	1	M	N
7	0800	3 A/E Tasks - Basic Plumbing Skills	3 A/E Tasks - Purifier Operation and Maintenance	2	H/T	N
	0930	3 A/E Tasks - Purifier Operation and Maintenance	3 A/E Tasks - Basic Plumbing Skills	2	T/H	A3/1:4.6
	1300	Chief Engineer's Topics	Chief Engineer's Topics	1	Chief Eng	N
	1400	Self Study or Makeup (if needed)	Self Study or Makeup (if needed)	2	TBD	N
8	0800	Qualification Boards - All Cruise Check-Offs Due	Qualification Boards - All Cruise Check-Offs Due	2	ALL	N
	1300	No PM Classes - Prep for Final Exam	No PM Classes - Prep for Final Exam			N
	1400	License Prep. Final Exam	License Prep. Final Exam	2	S	N

Fig. 4. 2021 cruise engine faculty planning meeting.


Fig. 5. 2021 Cruise students practicing confined space entry.

Student Feedback

The CE103 and CE303 courses have continuously evolved, based on feedback from the MET program's industrial advisory committee, program graduates and their employers, and from students. Results of student surveys from our 2021 summer training cruise are shown in Fig. 6.



SAFETY
1. I feel safe during the hands-on aspects of my training when supervised by the engineering training officers.
2. I feel safe during the hands-on aspects of my training when supervised by the MTO training officers. (Enclosed Spaces/Line Handling/Ballast)
3. I feel safe during the hands-on aspects of my training when supervised by the ship's Engineering watch officers.

TECHNOLOGY
4. I feel that I am adequately exposed to the most current merchant marine engineering technology.
5. I feel that I am adequately exposed to the merchant marine technology that I will see in industry upon my graduation from MMA.
6. I believe that the classroom training on board the training ship expands my understanding of the ship's systems.

MMA PERSONNEL
7. I believe that the engineering training officers on board the ship are adequately credentialed to teach on board the training ship.
8. I believe that the engineering watch officers on board the ship are adequately credentialed to teach on board the training ship.
9. I believe that the engineering training officers make the best use of time available to educate me about the ship and its systems.
10. I believe that the training officers are available to assist me in my education on board ship, in class or in the engine room.
11. I believe that the engineering watch officers are available to assist me in my education on board ship or in the engine room.
12. I believe that the MTO training officers are available to assist me in my education on board ship and in the classroom. Enclosed (Spaces/Line handling/Ballast)
13. I believe that the training officers on the ship are a valuable educational resource to me during my cruise.

OVERALL EXPERIENCE
14. I believe that this training event is unique in that it provides technical education in a hand on at sea setting.
15. I believe that sailing on the training ship has given me a better understanding of life in the merchant marine and better prepared me for this career path should I choose to sail.

Fig. 6. 2021 cruise student survey results.

How Did We Do?

Students were asked to complete a survey on their cruise training experience and their responses were tallied as shown in Fig. 6. Fifteen questions covered a range of training and cruise experiences, and students were asked to rate their thoughts on a scale of 1 (strongly disagree) to 5 (strongly agree). As Fig. 6 shows, the majority of students were very positive about their cruise experience. We would like to specifically discuss two areas (questions 4 and 5) which yielded significantly lower positivity rates than the other survey areas.

> Question 4: I feel that I am adequately exposed to the most current merchant marine engineering technology.
>
> The current training ship is 31 years old. The life expectancy of a ship is typically 30 to 40 years, so the students correctly note TSSOM does not have the most current engineering technology. MMA is expecting delivery in several years of a brand-new training ship that will address this issue. In the meantime, students are exposed to an array of commonly used shipboard equipment to operate and maintain during their cruise and maintenance workdays. The ship's equipment is always updated to comply with safety and environmental regulations, so the ship has a combination of cutting edge and older technology.
>
> Question 5: I feel that I am adequately exposed to the merchant marine technology that I will see in industry upon graduation from MMA.
>
> Student responses to this question were also notably less positive than others. However, they rated this question 3.8 out of 5, compared to 3.5 out of 5 for Question 5. We believe

this reflects the realization by many students that not every ship on which they may sail will have the most current technology.

Conclusion

We feel that the annual training cruise is a significant experiential learning opportunity for our students. As you have read, MMA's MET students operate, maintain, troubleshoot, and repair complex propulsion, electrical, and support systems while being supervised and mentored by experienced licensed marine engineering officers. The challenging curriculum provides context to the students about potential career opportunities and challenges while preparing them to progress on their chosen academic path. We were pleased to see that our survey shows that ninety-two percent of our cruising students agree (question 15).

References

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Biographies

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CDR HANK STEWART, US Navy (retired), associate professor of Engineering, joined MMA in 2014. He holds a BS from Maine Maritime Academy, MS in Management from the U.S. Naval Postgraduate School, and MMAS in Military History from the US. Army Command and General Staff College. He holds chief engineer, steam, motor, or gas turbine vessels, unlimited licenses, and a State of Maine first class stationary steam engineer's license.

DAVID WALKER is an instructor of Engineering and holds an AS, Eastern Maine Vocational Technical Institute. He has over 30 years of industrial experience; his area of expertise centers around electrical engineering and hands-on electrical applications. He joined MMA in 2011.