THE ESTUARY AS A CLASSROOM: HARNESSING INTERDEPARTMENTAL SYNERGIES, CAMPUS LOCATION, AND FACILITIES, TO IMPROVE STUDENT ENGAGEMENT IN MARINE TRANSPORTATION AND MARINE SCIENCE

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Abstract. This study seeks to enhance opportunities for authentic learning to improve retention of course content, increase student engagement, and raise ocean literacy. The California State University Maritime Academy (Cal Maritime) is located on the Carquinez Strait, in northern San Francisco Bay, California, USA. We integrated two courses in the Marine Transportation and Marine Science curriculum to facilitate weekly oceanographic surveys aboard one of Cal Maritime's small training vessels. Students in the integrated course worked together to develop voyage plans and navigate to sampling stations where students deployed water sampling instrumentation. We anticipated that the introduction of a real-life mission would improve student engagement by providing added purpose to the class periods. By working together toward a common mission goal, students would gain proficiency in ocean literacy, navigation, and vessel operations without instruction in the formal classroom setting. To facilitate communication between the students of the two courses, a senior level student was employed as Chief Science Officer (CSO). The CSO attended every meeting of the integrated course, and educated the students in the sampling equipment operation. Student learning and engagement was assessed at the start and end of the semester using a combination of course content questions as well as surveys

addressing attitudes towards ocean stewardship. While analysis of learning assessment is still underway, here we describe the steps taken to develop and implement the integrated course model, and report on student engagement. We suggest that maritime universities should seek to identify similar interdepartmental synergies to improve student learning outcomes and student engagement.

Keywords: marine transportation, marine science, authentic learning, maritime university, San Francisco Bay

Introduction and Project Goal

Authentic learning (AL) is learning through complex problem solving of relevant, real-world issues that are of concern to the student participants. AL is often interdisciplinary, and requires both student collaboration and peer to peer education. The authentic learning model challenges traditional models of teaching (i.e. the traditional lecture), and has been shown to lead to higher levels of interest, and increased retention of learned skills (Lombardi, 2007). AL is considered a high impact practice in higher education. There is a longstanding tradition of AL in maritime education and it is intrinsically incorporated into the curriculum of Cal Maritime's license degree programs. This project builds on existing AL in marine transportation curriculum, and expands it through a connection to scientifically relevant marine science research.

One of the greatest challenges to creating AL experiences in marine science is the ability to access the marine environment. Cal Maritime is located on the shores of the San Francisco Estuary (SFE), the largest U.S. west coast estuary (Nichols et al.1990), and one of the most studied estuaries in the world. Additionally, Cal Maritime owns several training vessels that are regularly operated as part of the license program student's sea-time requirements. These facilities are critical for AL in marine transportation and create the potential for opportunities for AL in marine science.

The project described here was funded by an internal university grant with the goal of increasing student learning and engagement in marine transportation and marine science by creating an authentic learning experience. Faculty in the Departments of Marine Transportation and Sciences and Mathematics took advantage of natural campus synergies by partnering two existing courses into a single authentic learning experience.

We predicted that the exposure of students to marine science research would improve their "ocean literacy." Ocean literacy is defined as 1) an understanding of the essential principles and fundamental concepts about the ocean; 2) the ability to communicate about the ocean in a meaningful way; and 3) the ability to make informed and responsible decisions regarding the ocean and its resources (COSEE, 2013). Ocean literacy is generally low in the U.S. (Belden et al 1999; AAAS 2004), including among U.S. university students (Cudaback 2006) such at Cal Maritime (Dewey et al. 2015). Maritime leaders will increasingly engage in ocean policy decision-making that should be made in the context of ecosystem and ocean-climate science. It is therefore in the best interest of professional mariners and thus maritime universities, to develop an ocean literate workforce.

Figure 1. Photograph of student and faculty participants in front of the training vessel *M/V Cub,* April 2017.

We anticipate that the introduction of a real-life mission will improve student engagement by providing added purpose to the class periods. We propose that by working together toward a common mission goal, students will gain proficiency in ocean literacy, navigation, vessel operations, and leadership, without instruction in the formal classroom setting.

Course Partnership

There is a high potential for synergy between marine science and marine transportation courses. Marine science courses can benefit by gaining access to the marine environment onboard training vessels; marine transportation faculty and students can provide safe and efficient operation on the water. Similarly, marine transportation courses can benefit through partnership with marine science courses by creating a mission to focus vessel operations training; giving marine transportation students the challenge of vessel operations to support marine science research surveys creates real-world challenges for students to solve.

Two existing courses, Navigation Piloting Lab (DL 301) and Oceanographic Instruments and Analysis Lab (MSC 200L) were partnered during the spring 2017 semester (Fig. 1). DL 301 is a weekly three-hour course where students demonstrate the practical application of voyage planning, communication, and terrestrial and electronic navigation on a power-driven small boat. Students enrolled in MSC 200L meet for 4.5 hours weekly to learn modern methods in oceanography, including the use of modern oceanographic instrumentation. Course content in DL 301 and MSC 200L was adapted to support the course partnership, but the original learning outcomes and student assessments associated with each course were maintained and students were responsible for meeting the course objectives of the course in which they enrolled. We conducted a student engagement assessment survey which consisted of four questions using a Likert-type scale and was presented to the students on week 14. Initial results of student engagement are presented in this paper.

The unique learning environment created by the intersection of ship handling and marine science also provided the opportunity for leadership development. A student was recruited to act as Chief Science Officer (CSO), serving as the link between the faculty and students. The CSO was a third-year license degree student who was pursuing a minor in Marine Science, and had previously completed MSC 200L. The CSO was responsible for weekly cruise preparation, timely sampling and collection, on-station coordination of equipment operation and deployment, and corresponding safety protocols. The CSO established assignments for each sampling position and conducted training and pre-departure meetings with students prior to each cruise.

A total of 18 students were enrolled between the two course sections. The vessel used for conducting the oceanographic surveys was 18.8 meters (65 feet) long, with a draft of 1.8 meters (6 feet). Instruments deployed on stations included a Seabird Scientific SeaCAT 19Plus profiling CTD, 10L Niskin bottles for sampling bottom water, Yellow Springs Instruments ProODO dissolved oxygen sensor, Secchi disks, and plankton nets. Water was collected for later determination of inorganic nutrient concentrations, suspended sediments, chlorophyll-a, and phytoplankton identification. The students conducted a total of nine underway surveys during the 16-week semester.

The first partnered class occurred during week two of the semester and was used for vessel and laboratory familiarization and safety. During week four, all students deployed the sampling gear at a single station and faculty hosted a professional oceanographic research technician and vessel captain to observe and advise. By week five, students were completing systematic estuarine surveys and taking on increased levels of responsibility for the project. The students were encouraged to take command of each research cruise and lab analysis, with the CSO acting as the liaison between the science team and piloting students. Students were responsible for getting and keeping the vessel on station, facilitating sampling, communicating when sampling was complete, and sharing the results with each other and the scientific community.

Marine science students were divided into three sampling teams of three or four students and the teams rotated each week. Marine science students who did not participate in the weekly survey would spend the class period working in the laboratory to analyze and process samples that were collected during the previous week's survey.

Initial Conclusions

This project attempted to increase student engagement and ocean literacy through the promotion of peer-to-peer authentic learning. The observation of student engagement was inspiring. Students from both courses actively participated in the sampling operation, and DL 301 students were exposed to additional authentic learning by employing the otherwise stationary cargo boom to deploy sampling equipment. In five weeks, all students were competent in the mechanics of the operation, and were assisting with equipment deployment and recovery under the direction of the CSO. The initial time on station of 15 minutes was quickly shortened to five minutes, even with different students operating the water sampling equipment.

Results from the Student Engagement Survey were overwhelmingly positive. Students reported discussing the class to peers both at Cal Maritime as well as outside of the campus community (Fig. 2). All the marine science students "strongly agreed" that the partnership improved the curriculum and was worth campus resources and instructor time. Similarly, marine transportation students felt that the partnership improved the curriculum (70% "agreed", 30% "strongly agreed") while 57% "agreed" that the partnership was a good use of campus resources (43% "Strongly agreed").

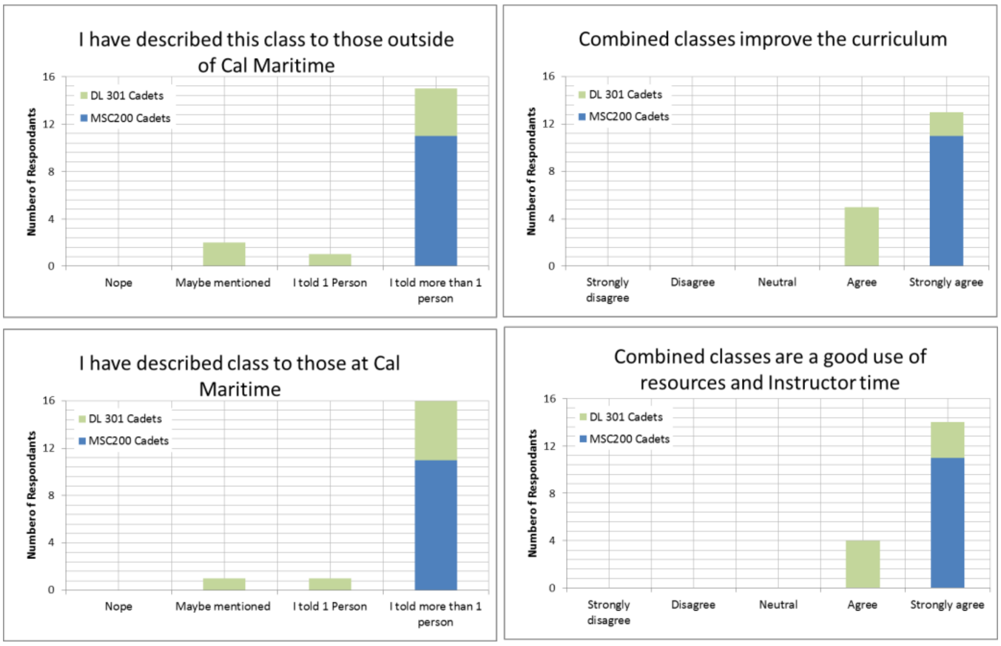
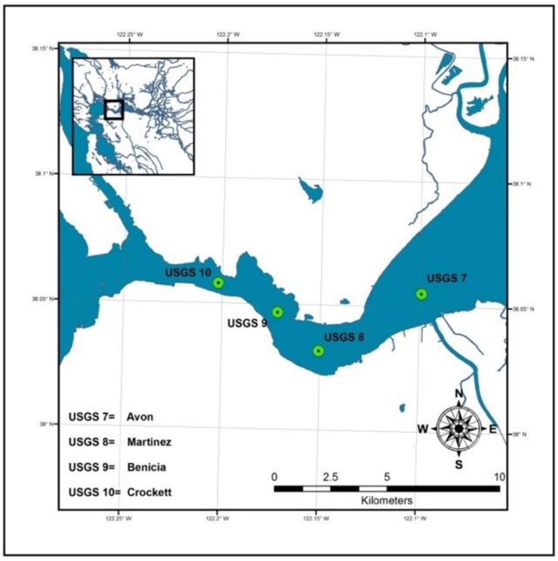


Figure 2. Results from the Student Engagement Survey conducted during week 14 of project. Students were asked to respond to questions using a Likert–type scale. Marine science student responses are in blue; marine transportation student responses are in green.

The CSO position was among the greatest successes of the project. The selection of a third-year student pursuing a minor in marine science and a major in a maritime license-granting program was an excellent fit. The CSO was an integral role in the course integration, and the lead for all sample collection. The CSO gained experience with navigation, ship handling, and use of scientific equipment while developing skills in communication, time management, problem solving, data processing, and teamwork.

One challenge of the course partnership was our limited ability to scale the program up to integrate more than one section of DL 301, and six sections of DL 301 did not have the opportunity to participate. An additional challenge was that, to maintain consistency of sampling, the DL 301 students in the integrated section were restricted to a single repeated voyage with four waypoints (Fig. 3). All other sections of DL 301 rotated through two additional routes, providing different opportunities for navigation and vessel traffic interaction.



Next Steps

The next goal for this project is to identify additional areas for improvement, and continue to collect data which will give depth to our initial survey results. We received support for the 2017-2018 academic year and will continue to develop the partnership between marine transportation and marine science. Assessment of student learning will be ongoing and our results will be used to guide curriculum development. Peer to peer education was a critical piece of this project, but was most successful when there was some level of formal direction. We plan to increase peer to peer instruction and marine science student involvement in the voyage planning process. We will also improve oceanographic and weather observation instrumentation for the training vessel. We hope that students will contribute meaningful data to the marine science community through the dissemination of scientific data reports and online data repositories. Looking beyond the 2017-2018 academic year, we hope to integrate additional marine science lab courses with other DL 301 sections. We would like to explore the potential to invite marine science students from other institutions to join our surveys as a means for university outreach and student recruitment.

Figure 3. Map of marine science survey waypoints occupied weekly during spring 2017.

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