Title
Sailing to Save the Seas: Marine Science Education on a Working Tall Ship

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I. Introduction

The history of science is a history of experiential education. The earliest wonderers could not have made their discoveries without laying their hands on and doing, without exploring the world through their senses and noting their observations, from which grew more inquiry. Only in the last few centuries have we organized science neatly up in a single row of facts to be marched through children's heads, as if any child we know listens to what they are told. Nowadays, to get students engaged in science, we must offer them experiences outside of the traditional classroom. Students need more than a lab table experiment mixing two chemicals that have been placed in front of them, or cutting up a withered frog with no connection to the natural world outside their windows. The intention of this curriculum is to reach young students, with their sense of wonder intact. Aldo Leopold observed that there is "an innate awareness in children that often is lost in adulthood. (Simpson, p119)" Ralph Waldo Emerson wrote, "Few adults can see nature. The sun illuminates only the eye of the man, but shines into the eye and heart of the child. (Simpson, p119)" We need to not only reach children while they maintain this innate awareness, but stoke the fires that it creates. If we can do so, we will create a passion that will last through high school, and puberty, and teenage skepticism, and help these future scientists find the answers to the world's most pressing environmental problems.

The tall ship *Bill of Rights*, a 136' Gaff Rigged Schooner owned by the South Bayfront Sailing Association, is an ideal platform to offer a marine science experiential education program to the youth of Chula Vista. With a 16 bunk classroom space in the "A" compartment, a large, two-table salon area, multiple small boats and ample deck space, the *Bill of Rights* can accommodate approximately 20 students with chaperones for day or overnight programs. The vessel currently spends most of her time on the San Diego Bay, between her berth in Chula Vista and the mouth of the bay in Point Loma. This makes her the ideal platform for groups wanting to explore their local waters.

II. Background – Global need

A. Need for more scientists

The decline in young people pursuing careers in science has become so pronounced as to be called by some "a crisis in American science education" (Girod et al, 2010). Even now in this, the age of science, technology and innovation, fewer and fewer students are choosing to further their education in math, science, technology, and engineering. Over half of the scientific workforce in the US is over the age of 40. However, as these scientists age and retire, we are not graduating young scientists to take their place (Talley et al, 2011). As the world faces ever increasing environmental issues, such as climate change, sea level rise, marine pollution, renewable energy demands and biodiversity loss, the United States stands to lose it place as a strong leader without a population of engaged young scientists. This decline in young scientists is also seen in countries around the world including England, Scotland, Wales and other EU countries (Bennett & Hogarth, 2009).

This need is recognized across the country, as evidenced by the creation of the Next Generation Science Standards (NGSS) and the focus on the STEM (Science, Technology, Engineering, Math) curriculum. These standards are created on a national level, although adoption and implementation on a state, district, school, or classroom level varies considerably. California is a national leader in NGSS implementation, while many east and midwest states are slower to join the initiative. While a focus on STEM subjects is a first step, it is becoming increasingly apparent that our methods of teaching these subjects needs to be revamped. Student's perception of these subjects also needs to change if we hope to entice more students to become scientists. Science needs to be seen by students to be engaging and directly applicable in the real world.

B. Students perceptions of science and as scientists

In their paper "Would YOU want to talk to a scientist at a party? High School students' attitudes to school science and to science" Bennett and Hogarth (2009) examine how students view both classroom science and real world science, and their interest in going into the science field. Although this study was conducted in England and Wales, the discussion and results could just as easily be applied to high schools in the United States.

The study assessed the attitudes of 11, 14, and 16 year olds toward toward science in the classroom and real world. The study looked at the student's views of working scientists and real world science, and also at students views of themselves as scientists in their science classes. This study, and other earlier studies, found that student's view science as difficult, irrelevant to their lives, boring, only for boys, as causing problems in society, un-cool, non-lucrative, or of value to society but not of interest for them personally. They found that these attitudes increased as students grew older, with a larger percentage of 11-year olds being interested in science particularly biology and natural sciences than among14 year olds, and an even larger drop by age 16 (Bennett & Hogarth, 2009).

These findings seem to indicate that a change in teaching methods for science should happen at a young age, so as to grab the attention of students when they are still naturally interested in science. If students can be shown, at age 11, the relevance and application of science for their daily lives, perhaps more students will choose to study science at age 16 and beyond.

Similarly, Girod, Twyman, & Wojcikiewicz (2010) in their study of two 5th grade classrooms, aimed to learn more about students views of themselves as science learners and "science type" people and their interest in science. They utilized a control classroom which was a typical science curriculum being taught simply for cognitive, rational understanding. Their treatment classroom was taught with methods for experiential, aesthetic education. They found that students from the treatment classroom self-reported higher levels of interest and a stronger view of themselves as scientists on post-tests than students from the control classroom (Girod et al, 2010).

C. Validity of and need for Experiential Educational

As adults, we learn new lessons through solving problems. By working something out for ourselves, we come to understand the details of a situation and how to best approach a similar situation the next time we encounter it. We create a lasting understanding of the issue at hand by thinking critically about how best to approach and solve our problem.

Rather than follow this model in schools, traditional curriculum often takes the approach of handing down knowledge to students. We being from the beginning and tell students exactly what we want them to know until we reach the end. A few students are able to memorize these facts, which are then forgotten by the time the next school year arrives. This is a particularly devastating approach for a topic like science, where the interest lies in identifying a problem and figuring out how to solve it.

Experiential education as a movement was started in the 1970s, with the introduction of programs such as Outward Bound and other adventure schools. However, educational movements centered around first-hand teaching experiences have been championed since the early 1900s in such programs as the nature study movement of the 1920s, the conservation education movement of the 1930s and the environmental education movement of the 1960s (Smith, T.E, Knapp, C., Seaman, J., Pace, S., 2011). John Dewey, educator and philosopher, advocated experiential education in the 1930s. His work in education and curriculum design and organization at University of Chicago and Columbia University has helped shape educational design theory and the experiential education movement (Smith, T.E., Knapp, C., Seaman, J., Pace, S., 2011).

Experiential education does more than just change how students learn material. It affects the amount of material they learn, and retain for future use, it affects the way they view learning both in and out of school, if effects the way they apply the knowledge learned to real world situations, and it affects efficacy – how positively they view themselves as learners (Girod, et al, 2010, Talley et al, 2011. Smith, T.E., Knapp, C., Seaman, J., Pace, S. 2011). Students in experiential education programs or classes show higher interest, higher efficacy, and higher self-identification as scientists/science learners (Girod, et. Al, 2010, Talley et. Al, 2011).

In their study of 5th grade science classes and their paper entitled "Teaching and Learning Science for Transformative, Aesthetic Experience," Girod, et. al used pre- and post-tests to assess the student's levels of knowledge. Identical tests were given to students in the control and treatment classes, and post-tests were given immediately after and one month after the unit was completed. While scores on the pre-test were similar between classes, and post-test scores were only slightly higher in the treatment class, a truly interesting thing happened on the one month post-tests. Students in the treatment class, which was taught using methods aimed at a transformative, aesthetic experience often utilized in experiential education, retained significantly more information only one month after the unit than students in a traditional classroom. The scores for the control class ranged from 42.33%-66.5%, while scores for the treatment classroom ranged from 66.99% to 76.92%. The treatment class showed a closer range of scores, and the lowest score in the treatment classroom was still higher than the highest score in the control classroom (Girod, et. al, 2010).

III. Background – Local Need

A. Utilization of ocean instruction in Chula Vista

The city of Chula Vista is located in southern San Diego county on the southern tip of San Diego Bay. The city is currently invested in a waterfront redevelopment project to encourage business and recreation along the bay (Unified Port of San Diego, 2015). While the city's redevelopment project is encouraging community education, the school districts have yet to utilize this resource in their curriculum. The Chula Vista Elementary School District has 48 elementary schools – 43 public schools, 2 dependent charter schools, 3 independent charter schools. The Chula Vista Elementary School District has a 68% Hispanic student population, and 35% of students are not English speakers 45-68% are at or below poverty line (assessed by receipt of free/reduced lunch), making Chula Vista a neighborhood in need. (Chula Vista Elementary School District, 2015)

An added benefit of an experiential education program to a school district like Chula Vista is that it reaches across cultural and language barriers. A young student who is struggling to learn English may not understand the terminology that they are learning in a traditional science classroom, but an outdoor, on-the-boat experience where they are able to participate in a hands-on manner translates into any language.

B. Success of other local and regional programs

There are a number of other programs both locally and regionally that are proving to be successful in providing interesting, engaging, experiential marine science programs. There are two local programs providing marine science education to different neighborhoods around San Diego County. Ocean Connectors, founded by MAS MBC graduate Frances Kinney, provides marine science education opportunities for 4th, 5th, and 6th graders in the National City School District. Ocean Connectors incorporates both in-class instruction and field experiences through a whale watching excursion.

Another local organization is the Ocean Discovery Institute (ODI). Through their work in the City Heights neighborhood of San Diego, ODI focuses on providing marine science experiences to underserved youth. They have a wide range of programs, from all ages volunteer community clean-ups to an immersive scientific research program in the US and Mexico for high school students (Pisbe, C., 2015). The high school program, known as Ocean Leaders, has seen 56 participants in the last 5 years, with more than half of the students returning for more than one year. 73% of students who participated in this program have declared college majors in science or conservation (Talley et al, 2011). The success of these and other local organizations seems to indicate that there is a desire in neighborhoods around San Diego County for marine science programs that engage students in and out of the classroom and enhance their science education.

Regionally, there are other tall ship programs that have been highly successful. The LA Maritime Institute (LAMI) the former owner of the *Bill of Rights* has been running their TopSail Youth Program since 1992. They cater to schools in the LA area and beyond looking for team building and adventure learning experiences. The TopSail Youth Program has been so successful that LAMI was able to commission two brand new vessels, launched in 2002 after a decade of operation (LAMI, 2014).

Another regional success story is that of the Ocean Institute in Dana Point. Their programs incorporate an historical tall ship experience onboard the vessels *Pilgrim* and *Spirit of Dana Point* and also an in depth marine science research opportunity in their Ecology Learning Center and the new Maddie James Seaside Learning Center, and onboard their research vessel *Sea Explorer.* The facilities and programs at Ocean Institute are ones that any organization would strive to emulate, with programs, vessels, events, and activities that appeal to and can accommodate the entire community (Ocean Institute, 2015).

The success of these other local and regional programs indicates that there is a desire in the area for on the water and about the water education. San Diego County is deeply involved with it's surrounding waters, and it is important that our youth learn about them from a young age. The environmental challenges facing our oceans in the coming years are staggering, but programs such as these are building ocean stewards, often from students who might never have engaged in science.

IV. Research/Methods

A. Backwards Design

Backwards Design is a curriculum design method that was recommended to me by many friends and colleagues with educational and curriculum design backgrounds. This method was used heavily by a colleague of mine in her curriculum development overseas with the peace corps, and she especially emphasized it's effectiveness and saw it's possibilities for an experiential education program (Klebes, K, 2015, personal communication).

The Backwards Design process can be broken down into three main stages: 1) identify desired results 2) determine acceptable evidence 3) plan learning experiences and instruction (Wiggins & McTighe, 1998). These steps are especially important in planning an experiential education curriculum like the one I've developed. It is very east to simply plan fun activities when developing an experiential education program, but for the program to truly be effective, and in the hopes of integrating the tall ship curriculum into the mainstream school districts, more thought must be put into the learning objective and goals. By identifying your learning goals first, activities can be modified accordingly, rather than attempting to piece together a lesson based around an activity. Developing new activities is much easier when you have an idea of why these activities are being performed.

In their book *Understanding by Design*, Grant Wiggins and Jay McTighe delve into the meaning of understanding and discuss how students learn in different ways. They discussed six facets of understanding, and how strength in different facets affects how a student best demonstrates their understanding. While this discussion is a bit beyond the scope of this paper, it was very informative and worth considering in design (Wiggins & McTighe, 2015).

The key aspect that I incorporated into my curriculum from the backwards design was the use of key questions, which I called guiding questions in my curriculum. These guiding questions are designed to give focus to the lesson and encourage the students and the teacher to think about the learning goal during their activities.

B. NGSS/EEI

The Next Generation Science Standards (NGSS) are the result of a collaborative effort between the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve. First, the *Framework for K-12 Science Education* was developed, then states are developing their NGSS curriculums. There are three dimensions of the NGSS: Practices, Crosscutting Concepts, and Disciplinary Core Ideas. Practices and Crosscutting concepts are things that are applicable to all areas of science. The disciplinary core ideas are overarching ideas that can become more focused as students get older (http://www.nextgenscience.org/three-dimensions, 2015).

Within each module, I identified the disciplinary core ideas that would be applicable for each lesson. The lessons often covered many different core ideas depending on how the discussion was structured or focused, and sometimes a lesson might cover a whole group of core ideas.

Among the states California is a leader in their development of curriculum content in line with NGSS. One of the ways that California is leading this program is with the Education and Environment Initiative, which is the first K-12 NGSS environmental education curriculum in the country. In this curriculum, the 5th grade segments focus on water – the water cycle, fresh vs. saline waters, the differences between freshwater and salt water ecosystems, etc (www.californiaeei.org/curriculum/, 2015). For this reason, my curriculum is focused on 5th grade students, although the ideas and activities in this curriculum could easily be adapted for other ages.

C. Other tall ships

In creating a curriculum I drew on the current curriculums of a few existing tall ships, specifically that of the Tole Mour. The Tole Mour has been sold into private service and is now sailing in the Caribbean, but until the fall of 2014 she was home ported in LA, and taught a marine science curriculum in the Channel Islands and Catalina Island. The content of their curriculum and the capacity that they had available (including touch-tanks, aquariums, and a lab on-board) are very different from the *Bill of Rights*. However, getting an idea for how to set up a curriculum while keeping in mind the issues of being on board a moving tall ship with all of it's working parts was invaluable.

V. Assessments

Assessments and evaluations are extremely important for program development. The purpose of this curriculum program is that it is effective in teaching students marine science topics thorough experiential activities. To determine the effectiveness of the program and areas for improvement, assessments are imperative.

The first type of evaluation that should be developed for this program is a formative evaluation. A formative evaluation "takes place before or during a project's implementation with the aim of improving the project's design and performance (Evaluation Toolbox, 2010)." The best type of assessment to undertake during the pilot programs onboard the *Bill of Rights* would be an observational assessment. During this type of assessment, while one person led the module, another would remain in the back and observe the module. They would want to observe the teacher, the students, the setting, and the interactions (Powell & Steele, 1996).

While the actual development of assessments is beyond the scope of this project due to time restraints and no assessment has yet been developed, it will be an important next step as we move forward with implementing the curriculum.

Resources

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