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### **Abstract**

The Sampling the Sea Project is a pilot online resource for teachers and students in grades 9-12, designed to improve learning beyond traditionally targeted cognitive dimensions such as *knowledge*, to include affective dimensions of learning such as *attitudes, skills, intention, and efficacy*, outcomes of sea food sustainability science, by means of specially designed curricula and active social media participation, with a multi-source evaluation component. The chapter provides overviews of the need for ocean sustainability curricula, the Sampling the Sea Project, pedagogic foundations, the ocean science sustainability curriculum, the infrastructure/platform, the justification for and nature of social media activities within the curriculum, the evaluation approach, and summary results.

### **The Need for Engaging and Participative Ocean Sustainability Curricula**

The purpose of this chapter is to summarize how an online ocean sustainability curriculum can be developed within a pedagogical framework and in accord with ocean science education standards, integrated into an online secure K-12 platform employing social media, and evaluated for both outcomes and process, using multiple data sources, as a model approach for similar projects.

The worldwide collapse of fisheries and subsequent impact on ocean health has reached crisis proportions (Halpern et al. 2008). One-fifth of the protein humans consume comes from the sea. Global seafood catch has dramatically declined for two decades while human populations grow, commercial fishing extends farther into the oceans, and pollutants and misuse damage ocean ecologies. Many marine species around the world are now threatened or endangered. It has been estimated that 90% of the world's large predatory fish (e.g., tuna, swordfish, shark, and cod) have been removed from the ocean (Myers and Worm 2003). The pending global crisis dwarfs other food issues, yet oceans garner little attention. Most people are too removed from the sea in their daily lives to understand that crises exist; hence, the demand for sustainable solutions is limited. Thus it is vital to engage the next generation of consumers in a global dialogue about the way we harvest and consume seafood if we are to create a cultural consensus to address this problem (Cava et al. 2005).

Ocean literacy curriculum units, lessons, and activities centered in issue-based learning can be used to increase opportunities to engage students in active and authentic ocean science inquiry (Wilmes and Howarth 2009). These opportunities can now be enhanced through the use of online social media in support of participatory learning in, across, and outside of classrooms. Students can share data, stories, and media while they learn from other students and their own content creation. This process also engages the same social media skills they are learning and developing outside of the classroom. Empirical research is needed to gather data and test theoretical predictions to support the design and integration of best practices for use of social media tools in education pedagogies.

This chapter briefly summarizes the Sampling the Sea project—its objectives, theoretical foundations, curriculum and activities, platform and social media, participants, and outcome and process evaluation plan, and summary results.

## **The Sampling the Sea Project**

### ***Overview***

Sampling the Sea (StS) is a pilot project of DigitalOcean, an ocean science education and social networking infrastructure project to create international, multi-generational communities working for ocean conservation, developing in interdisciplinary collaboration among the Carsey-Wolf Center, the Bren School for Environmental Science & Management, the Marine Science Institute, the New Media Research Institute, the Department of Communication, and the Department of Film and Media Studies, all at the University of California, Santa Barbara (see <http://www.cftnm.ucsb.edu/Programs/EMI/Research/SS.html?pkey=1990>). This chapter reports on the first year, a one-year pilot project including 10 months of development and 2 months of test usage. Ongoing development, usage, and evaluation will depend on funding.

StS determined that other efforts to inform the public about sustainable fisheries were available online (e.g., more than 120 Facebook groups on this topic in July of 2010) and through informal education venues (e.g., Seafood Watch, Marine Stewardship Council, Seafood Choices Alliance) and through a small number of restaurants aligned with the philosophy of the sustainable food movement, but few efforts were focused in the schools. Furthermore, as the consumption of seafood is not limited to coastal communities, this topic could be used in schools nationwide.

StS uses collaborative digital technologies to create a dynamic social learning environment that introduces middle and high school students in classes in the US and other countries using a secure online environment (ePals) to collect and share scientific data, media, and stories about human impacts on the ocean in ways that are fun, intellectually challenging, and rooted in peer interaction. The general goals of the long-term StS project are that student participants from around the world learn about seafood sustainability through curriculum unit lessons and activities, collect and share data about seafood choices in their communities, learn how these choices affect the health of the world's ocean, and discuss and create (within their classes and across classes) materials about the curriculum topics through social media. (For a 4-minute audio overview, go to <http://my.sxsw.com/events/event/776> and click on Media; for a 3-minute slide overview, go to <http://www.youtube.com/watch?v=tPyNbPzoWAY>.)

### ***Pedagogic Perspectives***

From the early development stages, the StS project was guided by a model that elaborated participation through social media as a process for improved ocean literacy. Developing the curriculum and evaluation required integrating multiple theories of learning (*constructivism, cooperative learning, connectivism, transformative learning, community of inquiry*, and the *unified theory of online learning*, for instance); as well as an environmental education framework (NAAEE, 2004) and the Ocean Literacy Principles (<http://www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf>). The goal of the developers was to provide a curriculum that met U.S. National Science Education Standards (NSES) for teaching, and targeted cognitive dimensions of learning such *knowledge*, as well as *affective* dimensions such as *attitudes, skills, intention*, and *efficacy*; important but often overlooked aspects of environmental science learning (McBeth, Hungerford, Marcinkowski,

Volk, and Myers 2008; NAAEE 2004; "NSTA Position Statement: Environmental Education" 2010; Ramsey & Hungerford 2002). This section briefly defines and describes how these theoretical frameworks and perspectives were integrated into the project.

Teaching skills- and issue-based science has been endorsed as a best practice by the National Council of Teachers of Mathematics, the American Association for the Advancement of Science, and the National Council for the Social Studies (Ivers and Barren 2002). Skills-based science learning is grounded in *constructivism* which relates the process of active learning through the construction of knowledge, weighing new information against previous understandings, thinking about and working through discrepancies (individually and with others), and coming to a new understandings (ASCD 1992). With a focus on sustainable seafood as context for an issue-based approach for teaching ocean science, StS was able to incorporate constructivist theory into the curricula design.

One of the central goals of StS was to provide a platform for students to learn through the *cooperative* sharing of knowledge (seafood science and stories). A *cooperative learning group* is defined by five characteristics: positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing (Ivers and Barren 2002; Johnson and Johnson 1999). In StS, group participation through curriculum activities was emphasized to foster enhanced individual- and group-level learning opportunities.

*Connectivism* posits that learning (defined as actionable knowledge) is not entirely under the control of the student and can occur under shifting conditions where new information is continually being acquired (Siemens 2005). Learners need to draw distinctions between important and unimportant information, and recognize when new information alters the landscape. Erickson et al. (2010) argue that *transformative learning* (changes in perspectives) about sustainability requires understanding of the interrelationships of environment, economic, and social factors, at individual and societal levels. Students participating in the StS pilot project were exposed to a blended curriculum of “in-seat,” extracurricular, and online experiences. Further, the complexity and connectivity of seafood sustainability issues (consumerism, methods of harvest, and trophic level feedbacks, for example) are linked intrinsically through connectivist and transformative perspectives.

A final need for StS was to integrate traditional theories of learning with emerging and evolving theories that describe learning interactions that occur online. A *community of inquiry* is one theoretical framework developed for describing how online learning technology is used to create online learning communities and networks (Benbunan-Fich et al. 2005; Garrison et al. 2000). Anderson’s (2008) *Unified Theory of Online Learning* claims that quality online learning, like all learning, should be knowledge-, community-, assessment-, and learner-centered, and include feedback, assessment and reflection. Anderson’s model of eLearning illustrates a relationship between human actors as teachers and learners, their interactions with each other, and with content; and proposes that the major modes of online learning that should always be considered are collaborative, community-of-inquiry, and community-of-learning models.

These theories and frameworks provided the structure and support for the STS curriculum development, and a foundation for the evaluation.

### ***Ocean Literacy: Sustainability Through Environmental Education***

Educators and policy makers have proposed that tackling the problem of rapidly declining ocean health requires a massive effort at developing an “ocean literate society”—in

other words, broader awareness, knowledge, and concern for the ocean's influence on human health and our influence on the ocean among the world's citizenry ("America's living oceans: Charting a course for sea change", 2003; "An ocean blueprint for the 21st century. Final report", 2004; Cava et al., 2005; Day, 2003).

One path to achieving this goal is through the development and integration of an ocean-oriented approach to teaching science in K-12 education. Ocean literacy integrates research and perspectives from constructivist, connectivist, and environmental education frameworks, and targets both cognitive and affective dimensions of learning (attitudes and skills, for example). Both social media and ocean literacy can be linked *theoretically* to cognitive and affective learning; both are in need, however, of *evaluation research* to determine whether, and under what conditions, they can or should be integrated into the formal science curriculum.

Developing a curriculum for high school students—near-future decision makers—about the relationship between sustainable seafood issues and ocean health contributes towards building a foundation for the improved stewardship of these resources. Until recently however, ocean science curricula have been largely ignored in K-12 classrooms. In the US, this problem began to be addressed in 2004, when a consortium of government and non-governmental agencies (NGOs) including the National Geographic Society and National Oceanographic and Atmospheric Administration, and some 100 members of the ocean sciences and education communities crafted the ocean literacy framework. Comprised of seven essential principles and a subset of fundamental concepts, these guidelines support an ocean-centered approach to teaching science standards (Cava et al. 2005).

An early goal of StS's lead curriculum developer was to integrate the ocean literacy principles (based on an environmental education framework) into the StS curriculum. One of the key distinctions between environmental education (EE) and formal science education is that EE attempts to target other domains of learning in addition to knowledge (Pooley and O'Connor 2000; Stapp et al. 1969). These objectives are often referred to as affect outcomes (attitudes, feelings, sensitivity), skill outcomes (issue analysis and skill building), intention outcomes (willingness to act), and behavior (participation) (Final Report, 1979; Hungerford and Volk 1990; McBeth et al. 2008; Ramsey and Hungerford 2002; Simmons et al. 2004).

Therefore, from an evaluation standpoint, integrating traditional and online theories of learning, the ocean literacy principles, EE, and sustainable seafood science, supported the twin goals of providing a curriculum that targeted cognitive *and* affective learning, and a coherent model for assessing students' short-term ocean literacy learning outcomes. An organizational matrix linking StS units and activities with their associated EE domains, Ocean Literacy Principles, and NSES standards was created as a reference for the development of the before-after teacher and student survey instruments.

### ***StS Curriculum***

Through a series of informal workshops and discussions with educators held at the outset of the project, we learned that in order to make the Sampling the Sea program accessible to, and adopted by, science educators in the formal classroom, the curriculum would need to support several key but disparate needs. Three of these were chosen as most important. First, the curriculum must be oriented towards the National Science Education Standards (in the U.S., educators teaching at primary and secondary schools are required to teach to a set of national and state science standards and administer standardized statewide tests). Second, the curriculum

would need to be designed with enough flexibility to allow use by students under a variety of technology configurations (and barriers such as limited computer access). And third, the project must be designed and presented in such a way that students' and teachers' "down time" in learning and navigating the online interface was minimized, with the aim of maximizing participatory learning duration and outcomes.

An expert panel of ocean science educators developed five curriculum units, each with 3-5 activities, involving classroom content, media, and projects, out-of-classroom experiences, and online social media involvement. For the teachers, the activities include an overview, key concepts, learning objectives, time required, social media opportunity, materials required, student instructions, and additional print and online resources (see <http://www.stsproject.org/>).

**1. What's in the Water?** Students play a game modeling the life cycle and migration patterns of the Pacific salmon. Students compare and contrast ocean life in the epipelagic zone of the ocean. Students share information gathered as part of an in-class newsletter project with students partnered through ePals. They critique each other's work and co-create a collaborative blog on ocean life. Students participate in an online simulation following the migration of a young salmon to the ocean. They use online discussion forums and the ePals media gallery to compare and share results with students in other classrooms.

**2. Ocean Ecology.** Students are introduced to the concepts of ocean ecology through a series of interactive games and activities. Students share what they know about ecosystems with others by posting and describing photos of local ecosystems and/or components of their local ecosystems on a shared gallery space within ePals.

**3. Who's Fishing?** Students compare and contrast the techniques and challenges of fishing via several labs and activities. Students collect and graph data. Students analyze maps of worldwide fish imports and exports and discuss the impacts of the global fish trade. After learning about the pros and cons of various types of fishing, students use an online forum to discuss ways to make sustainability a marketable feature of seafood products.

**4. Fisheries Management.** Students engage in a mock fishing derby that simultaneously explores the history of the New England Cod fishery and illustrates the tragedy of the commons. Students use Google Earth to examine fisheries data from the Sea Around Us Project and the US National Marine Fisheries. Students read and share articles and case studies explaining fisheries management strategies. Students use the internet to visit Marine Protected Areas around the world.

**5. Sustainable Seas.** Students formulate a research plan to study local seafood consumption and collect fish and seafood market observations to test their hypotheses. Within the ePals environment, students share data, observations, and results along with images, video, and or text with their class and the Sampling the Sea community. Students design and create educational posters and bumper stickers to share, and comment on, and revise.

### ***The StS Platform***

One of the perceived risks for social media sharing inside the classroom is the potential for inappropriate content sharing, such as cyberbullying or "sexting." One response to this risk is to allow for moderated interactions within a closed network. Social networking platforms such as Ning and widely-used course management systems such as Blackboard and Moodle now provide a range of moderation tools for content, from moderation queues for pre-posted content, to flags for inappropriate content. A classroom-specific social network platform, ePals (<http://epals.com>),

has made teacher moderation the hallmark of its service. StS chose to partner with ePals as its initial social network platform. The ePals™ platform is built on an enterprise-level instance of the Telligent Community (<http://telligent.com/>) software platform. However, the StS curriculum and other tools are not hosted directly within ePals, so other platforms are possible in the future. ePals™ offered StS an early version of its LearningSpace™ service, which is a project-based learning environment designed for school districts. The chief advantages of the LearningSpace™ service, beyond its teacher moderation capabilities, are a combination of social media tools: wikis, forums, and image and video uploading/linking and commenting. In its early stage development and the pilot StS implementation, the LearningSpace™ suffered from some usability and other user interface issues, which will be improved in future versions.

The central activity of collecting fish names from local suppliers is supported by an online Data Collection Tool built in Adobe Flash™. The DCT was designed to help the student move from the common name of the seafood to its scientific name. This step was important for the tool to programmatically interface with other databases (e.g., FishBase and Seafood Watch). The DCT also creates a custom data visualization layer in Google Earth. The tool is connected programmatically to the uBio database of scientific names, the FishBase species database, and to the Monterey Bay Aquarium's Seafood Watch database. The uBio database maps species (and subspecies) names onto common names in dozens of languages. This was very useful for international schools.

Due to space limitations, the multiple components of the StS system, and the extensive software development required to integrate the various data sources, registration system, curriculum delivery system, and client-server architecture, with the ePals™ infrastructure, cannot be described here.

### ***Social Media***

A basic proposition of Sampling the Sea is that the use of social media and social networking within the curriculum should allow students to bring their outside-of-school media sharing expertise and interests into the classroom (Rheingold 2008) and enhance opportunities for peer-to-peer, or cooperative learning. StS embeds U.S. National Science Education Standards and essential ocean literacy principles within a philosophy and networked platform of asynchronous learning, social media, convergence and participation.

Asynchronous learning networks (Anderson, 2008; Hiltz and Goldman 2005) and collaborative media, such as online social media (Jenkins 2006; Kaplan and Haenlein 2010; Shirky 2009), can complement *conveyance* pedagogies (e.g., lectures) with *convergence* approaches (mutual construction of knowledge) (Hiltz and Goldman 2005; Siemens 2005). Jenkins et al. (2006, p. 4) propose that social media can offer students possibilities to integrate important new skills: distributed cognition, collective intelligence, transmedia navigation, and even play, as several examples.

The curriculum units listed in the Ocean Sustainability section provide suggestions, tools, and resources for integrating social media as ways of discussing, sharing, and creating experiences related to ocean sustainability. For example (one activity from each unit):

- 1B Students within their class engage in online conversations using the class discussion list about the pros and cons of salmon fishing.

- 2B Students photograph a meal eaten in a typical day, upload it to the ePals LearningSpace, and research the origin(s) of one component of another student's meal. Using the online discussion forums, they discuss the process of finding out where a food item comes from.
- 3C Students obtain a dozen digital photos tell a "fishing story" from somewhere in the world, and then create a short music video showing how people catch fish in different parts of the world.
- 4B Students search online for seafood choices available in local restaurants. They place the results of their search into a group edited web page (wiki)
- 5A Students share fish consumption data (common and scientific names, origin of catch, cost per unit, sustainability rating, etc.), photos/videos of fish, fishing, and fish markets, stories of fish as a family food choice and of fishing as a hobby or occupation. Students comment on other students' offerings. The fish data upload form available in StS is connected to online resources about sustainability (Monterey Bay Aquarium's Seafood Watch.org) and fish species information (Fishbase.org). The uploaded data can be used to create sharable research objects in the form of Google Earth layers and spreadsheets.

### ***Evaluation Plan***

As with other new technologies, the use of social media in the classroom requires careful studies to weigh its pedagogical benefits and associated risks. The StS project is designed to contribute to this effort through an integrated evaluation process. Outcome and process evaluation data were integrated from ePals and StS teacher and student usage data aggregated at the classroom and curriculum levels, and across relevant time periods; teacher and student surveys at the beginning and end of the StS pilot; teacher emails and responses to open-ended survey questions; insights from the curriculum developers; and experiences from all the project members. The teachers were self-selected, volunteering to participate in the project as a way to obtain additional ocean science curriculum and to continue using the online ePals system. Participation in the surveys by both teachers and students was anonymous (though linked across surveys and usage), voluntary, and in accordance with University and high school human subjects procedures.

The sets of survey questions for teachers, and for students, were developed after extensive review of other ocean literacy projects' evaluation efforts. This pilot study obtained selected ePals and StS usage measures, ranging from user logins, media uploads, forum activity, posts and comments per blog, conversations, and wiki activity, as ePals provided StS full access to the underlying code and database for its LearningSpace™ instance. Thus we were able to programmatically integrate user login and activities usage data with pre- and post survey responses (through SurveyMonkey) from both teachers and students. This integrated approach allowed analysis at the teacher, student, class, curriculum, and overall levels of analysis.

The general outcomes of interest at the student level of analysis were (a) the short-term influences (from classes, other students, and teachers) on students' seafood sustainability learning outcomes, as (b) moderated by participatory learning (students' and teachers' use of social media as part of their course sustainability activities). For example, different classes have different levels of accessibility to computers and networking, students have different levels of social media expertise, and teachers have different levels of ocean science and online classroom training.

As derived from the pedagogical perspectives, the measured effects included: *Knowledge* (change in students' knowledge of seafood sustainability concepts), *Affect* (change in students' attitudes, sensitivity, and feelings about seafood sustainability concepts), *Skills* (change in students' cognitive skills related to analysis about seafood sustainability concepts), *Intention* (change in students' verbal commitment and willingness to act on sustainable seafood issues), and *Efficacy* or locus of control (perceived ability to perform the intentions and change attitudes and behaviors about seafood sustainability), as well as more general assessments of the StS system and project.

We were also interested in the teacher level of analysis, including outcomes such as *Affect* toward seafood sustainability, and of the overall validity of providing social media as course tools in the formal classroom (considering barriers to use such as time, technology, and/or access, and perceived value and acceptance by educators and administrators as an effective learning tool) and general assessments of the StS system and project.

Finally, we also built in formative and process evaluations, to use initial results to revise the system and content, and to understand the challenges and opportunities of the social, pedagogical, technical, management, resource and analysis aspects for future projects. Due to space limitations, and the primary intention of summarizing this pilot project, we do not report specific evaluation results here. However, the next section summarizes lessons learned.

### ***Lessons Learned***

1. The work produced by the curriculum development team resulted in very high quality curriculum centered on sustainable seafood science. Each curriculum unit and activity was linked to NSES and Ocean Literacy Principles. Additionally, the curriculum was skills-based, which provided students an opportunity to engage in real field research related to consumer impacts (supermarket and fish market data collection and analysis, and the collection and sharing of images and other media and stories).

2. Over 200 classrooms were pre-registered through outreach efforts using NASA GLOBE and ePals' resources. Unfortunately, there was a high rate of attrition by the end of the program, due to aspects of each of the five foundational themes noted in section 8 below.

3. Through the development of a Rich Internet Application (Teachers' Assistant) for the LearningSpace™ platform, registered teachers (and their classes) and students accessed the StS curriculum on the project's Google site.

4. The development of the Data Collection Tool (DCT), a cornerstone feature of the StS curriculum (Unit 5a), created the capability for uploading and displaying collected fish and seafood survey data into a custom Google Earth KML file. The scientific names provided by the Data Collection Tool that map to Seafood Watch are often species or subspecies (e.g., coho salmon) that might require the student to know more information than was collected (e.g., harvest location). Also, the late delivery of the DCT precluded the majority of registered students from being able to use the DCT.

5. In the future, Sampling the Sea will likely need to glean information from the standard analysis tools that services expose to their customers. The experiment in total access to the ePals database gives StS a better understanding of the limits of what is possible, and will inform future evaluation efforts.

6. The goal of supporting cross-classroom collaboration through social media was not achieved. Students were not inclined to talk with each other in the LearningSpace™ (as reported



by teachers and actual usage), and since most of the social media features in what turned out to be a beta version of LearningSpace™ did not function well, it was difficult for students to share materials. Further, because of time pressures, and insufficient documentation of the procedures, teachers were not able to set up shared classes.

7. The process evaluation provided important information related to how teachers, classes, and students did or didn't use Sampling the Sea, and how certain features could be improved for future runs. Data collected for those teachers and students who did use the system and responded to both before and after surveys indicated small but statistically significant increases in some learning outcomes related to the five EE domains, including sustainable seafood knowledge. A regression analysis revealed that students' self-reported improved understanding of seafood sustainability and ocean health were partially explained by the *sharing* and *viewing* of stories and media, and science content. While these results are encouraging, it is emphasized here that they are based on a very small portion of teachers (n=6) and students (n=54-55).

8. As an example of one data source and the related process evaluation insights, the teacher comments were initially coded into 228 separate topics (i.e., one email might include two or three topics), then into 132 distinct codes (after standardizing across variants), and iteratively into a set of 13 general categories. These general categories reflect five foundational themes of *authorization* (5 topics), *curriculum* (28), *project* (38), *social media* (7), and *technology problems* (53).

9. Overall, the project's process flows, the data-collection procedures, and the evaluation components were all successful models for rigorous future evaluations of the DigitalOcean: Sampling the Sea project, and similar projects.

### **Conclusion**

Sampling the Sea was designed to support the critical need for improved ocean literacy, especially concerning sustainability. It seems unique in several respects. First, it may be one of the earliest projects to explicitly integrate National Science Education Standards and ocean literacy principles into a curriculum design for high school students. Second, it addresses existing recommendations put forward by the Centers for Ocean Science Education Excellence, the U.S. Environmental Protection Agency, the National Environmental Education Council, the National Science Teachers Association, North American Association for Environmental Education, and the National Oceanic and Atmospheric Organization, to empirically investigate the effectiveness of instructional materials in meeting the goals of environmental education and environmental literacy. Third, it builds on existing ocean related curricula to achieve the highest possible success at meeting academic objectives and provides some measures to compare future measures. Fourth, the operationalization of the evaluation model as a proof-of-concept design illustrates how the linkages and variables related to environmental literacy could be tested in a full (pilot) project implementation. And fifth, the outcomes obtained point to interesting insights into how new digital teaching tools and technologies like social media may affect learning outcomes in the five domains critical to environmental literacy (knowledge, affect, skills, intention, and efficacy), and point to how to refine the curriculum and evaluation model for a full implementation in a Phase II of StS.

Online learning environments that support participatory learning through social media tools hold promise for ocean literacy and other subjects in which knowledge sharing and the

exchange of ideas among students can increase academic performance, skill building, and expanded learning opportunities. Yet, funding and research to support the inclusion of digital tools in the classroom means many schools in the U.S. have only limited computer access. Further, the shifting focus from the use of the Internet and computers as purely research tools, to collaborative online learning environments, has not, as yet, been integrated into teaching practices. Cost, time, and effort for technology adoption are certainly barriers to acquisition, as is the need to guarantee security for students working in online environments

It is hoped that these early results in an emergent, transdisciplinary field of research will generate interest in developing and funding a full project implementation and Phase II evaluation of the Sampling the Sea program.

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