I. Introduction

The Gulf Stream Voyage (Hotaling, 2002) is one example of an Internet-based, multidisciplinary project that utilizes both real-time data and primary source materials to help guide students to discover the science and history of the Gulf Stream. The project was produced by the Center for Innovation in Engineering and Science Education (CIESE) and is one of several projects offered by CIESE that assist educators with the integration of technology, specifically real-time data, into classrooms.

As students work through the lessons contained within the project, they investigate the Gulf Stream current by accessing various data sources, investigate how the current affects the Atlantic Ocean and some of humankind’s experiences dealing with the current. This voyage includes activities relevant for marine science, earth science, chemistry, physics, biology, math, history and language arts classrooms. All of the lessons may be easily used in today’s technology-enhanced classroom.

Studies have shown that the use of engaging, authentic curricula that include relevant uses of the Internet by teachers and students improve student achievement in core subjects, and can promote higher order thinking, critical analysis, collaboration, and problem solving.

There is potential use of real-time data and databases with many audiences including: educators, the general public, policy makers, resource managers, and the media. The Gulf Stream Voyage is only one example of an educational application. As data sources and environmental sensors come online and available on the Internet, it is essential for research scientists to consider audiences beyond their own research community. The onus should not lie with potential users to decipher or interpret data; instead the scientific community should proactively create engaging, clear and concise displays of data in an effort to reach non-scientific audiences.

II. Real-time Data and the Internet

A. How the Internet is Effectively Used in Classrooms

Since 1994, the Center for Innovation in Engineering and Science Education (CIESE), located at Stevens Institute of Technology, has worked to promote the use of Internet resources in K-12 science and mathematics education. As one of the first groups to experiment with Internet infusion, CIESE sought to position this technology in a way that would justify the time, resources and effort necessary to make its use effective. CIESE explored applications of the Internet and enhancements to student learning that could not be accomplished through books or any other conventional means.

In refining CIESE’s position, potential applications of the Internet were judged by the criteria of “unique and compelling.” In considering whether an Internet-based classroom activity met these criteria, we asked two questions: (1) Can these learning activities be accomplished in any other way? and, (2) do the educational outcomes justify the still considerable effort teachers must invest to use the Internet effectively in the classroom?

Over the years, CIESE has identified five unique and compelling applications of the Internet for K-12 education:

- Use of real time data from governmental, scientific and commercial sources;
- Access to unique and primary source information;
- Telecollaborative projects using databases compiled by project participants;
- Student publishing on the Internet; and
- “Ask an Expert”—accessing topic experts through Internet sites and e-mail.
Until the availability of the Internet in classrooms, students had to use limited and outdated data sets to learn about dynamic earth systems. For years, talented teachers have used “event-based” activities to interest students and utilize current information on a topic; however, access to real-time data provides students with current information. Access to real-time data also provides authenticity and investment in concepts being explored that no textbook or historical data can. Using real-time data in the classroom engages students in the scientific process and in using technology in the same way as researchers: analyzing real data, formulating and testing hypotheses, and refining their ideas to account for the evidence collected (McGrath, 2001).

B. Advantages to Using Real-time Data in Classrooms

There are several advantages to using real-time data in classrooms including:

- infusion of inquiry-based learning;
- fostering problem-solving skills;
- addressing several learning styles;
- student relevance; and
- assisting English Language Learners (ELL).

Inquiry-based science and problem-solving activities that incorporate the use of real world data are advocated by the National Council of Teachers of Mathematics (NCTM), the American Association for the Advancement of Science (AAAS), and the National Science Education Standards as a powerful “avenue through which students can increase their science and mathematics literacy” (USDE 1995).

In the National Assessment of Educational Progress (NAEP) Science findings of 2000, results reveal a statistically significant increase in scores of those students who downloaded and analyzed data. There also exists compelling evidence that this approach to science instruction can improve standardized test scores (O’ Sullivan 2003).

The use of Information Technology and the Internet in classrooms is compatible with a wide variety of learning styles. It also enables the use of a broad range of engaging learning activities. The flexibility of Information Technology allows us to present and understand information using text, images, animation and sound to overcome traditional learning difficulties (Klice, 2003).

Using computers and real-time data in the classroom engages students principally because they enjoy using computers in the classroom. The use of technology also fosters 21st century workforce skills including digital age literacy, inventive thinking, effective communication and high productivity (Branford, 1999).

Technology integration has proven valuable in ELL classrooms. ELL students using the Internet in coursework have displayed enhanced motivation, increased language proficiency, improved academic achievement and demonstrated higher level thinking skills (Warschauer, 2000). Using the Internet, and in this case a real-time data project, provides an authentic purpose for ELL students to read, evaluate, and synthesize text and data.

Teachers trained effectively in the use of real-time data in the classroom tend to: feel better prepared to teach problem-solving skills; spend less time lecturing; report an improved ability to teach complex concepts; are better able to conduct small group learning activities; can more easily implement cooperative learning approaches; and are more effective in managing diverse learning styles (Yepes-Baraya, 2003).

III. Project Description

The Gulf Stream Voyage is an Internet-based multidisciplinary project which utilizes both real-time data and primary source materials to enable students to discover the science and history of the Gulf Stream. Students investigate the Gulf Stream current, its influence on the Atlantic Ocean, and some of humankind’s experiences dealing with the effects of the current. The Gulf Stream Voyage includes activities for marine science, earth science, chemistry, physics, biology, math, history, and language arts classrooms. All of the activities can be easily integrated into today’s technology-enhanced classroom.

The real-time data and databases utilized in the project include NOAA buoy data, ship observation reports, sea surface temperature data, current velocities of the Gulf Stream, meteorological data, SeaWiFS, and Global Drifter Program drifter data.

The Gulf Stream Voyage project has been used in grades 6 – 14 classrooms across the country and has been used successfully in Adult Literacy classrooms, teaching users how to access and interpret real-time oceanographic and satellite data, and how to use the information to solve real world problems.

The project lesson plans are divided into two sections: Core Lessons and Enrichment Lessons. The intention is for teachers and students to move through the Core Lessons to learn basic scientific and historic information about the Gulf Stream current. Once the basics are covered, then teachers and/or students can decide to work through a variety of Enrichment Lessons to build upon the core knowledge.

A. Core Lessons

The Core Lessons section is comprised of three lessons that expose students to some of the science and history associated with the Gulf Stream current. The Core Lessons are:

- Map of the Gulf
- History of the Current
- The Current Today

In the first lesson, Map of the Gulf, students are challenged to create a concept map (graphic organizer) to depict the connections of various factors involved with the Gulf Stream current and its movement in the Atlantic Ocean. There are three levels of concept maps that teachers can choose from to best complement the student ability level in their classrooms. This lesson is intended to serve as a pre-test or assessment of prior knowledge before beginning the project; however the same concept maps can be created by students at the end of the project to serve as a post-test.

The second lesson, History of the Current, is an exercise in cooperative group learning. Teams of students are challenged to investigate the effects of the Gulf Stream on sailing ship travel, to research methods that were used in the past to determine the location of the Gulf Stream, and to report historical examples of the influence of the Gulf Stream on early American history and industry.

The Current Today is the third lesson in the Core section. The lesson employs the use of student cooperative working groups to solve a real world problem, namely to locate the
Gulf Stream current in real time. Each student working group consists of three pairs of students. The first pair of students is provided with Internet links to key National Oceanic and Atmospheric Administration (NOAA) coastal buoys that provide water temperature, wave height and meteorological data. A second pair of students is provided with Internet links to real-time data as reported by ships currently traveling in the North Atlantic Ocean. This data includes:

- the location of the ships in real time;
- meteorological data
- water temperature and
- wave height in the vicinity of the ship.

A third pair of students is provided with Internet links to near real-time satellite images mapping sea surface temperatures. Each pair of students is responsible for collecting specific information and answering questions pertaining to their assigned data source. The students then report back to their larger team group and combine all of the collected data to determine the current location of the Gulf Stream.

After completing the Core Lessons, students should be able to:

- use a graphic organizer to depict basic facts about the Gulf Stream current;
- discuss the history of the Gulf Stream as it pertains to early American history;
- describe effects of the Gulf Stream on ship travel;
- describe historical methods of determining the position of the Gulf Stream; and use real-time data and modern methods to determine the current location of the Gulf Stream.

B. Enrichment Lessons

The Enrichment Lessons section comprises six lessons that expose students to some of the effects the Gulf Stream current has on climate, weather, organisms, ship travel, and history. The Enrichment Lessons include:

- Climate
- Biology
- Fishing
- The Amistad
- Drifters
- Ship Movement in the Gulf

The Enrichment Lesson on Climate leads students through a series of six links to various cities on both sides of the Atlantic Ocean. The students must record the latitude and longitude of each city, local weather, and average climate conditions to determine if they are influenced by the Gulf Stream.

In the Biology lesson, students learn to obtain and interpret sea surface temperature and chlorophyll-a concentrations data. Students learn to determine, in real time, the locations of concentrations of phytoplankton in the region of the Gulf Stream. Students are also challenged to investigate other regions of the ocean to look for patterns in distribution of phytoplankton.

Does the Gulf Stream have an effect on fish distribution in the Atlantic Ocean? In the Fishing lesson, students partner together pretending to own an East Coast fishing fleet with boats currently in Cape Hatteras, North Carolina; Boston, Massachusetts; and Halifax, Nova Scotia. The company only has the resources to send one boat out to fish for yellowfin tuna. The students must first collect background information about yellowfin tuna including normal geographic range, normal temperature range and optimal temperature range for the fish. Students also collect near real-time satellite imagery of the location of the Gulf Stream and real-time buoy data. Students then predict the best location to dispatch their fishing boat in order to hunt for yellowfin tuna. The lesson is intended to provide students with a general understanding of data collected on sea surface temperature, and how it is used by a variety of professions, not just research scientists.

On the morning of August 26, 1839, the Amistad appeared off the tip of Long Island, New York. The Amistad was a sailing vessel involved with slave trade, running between the Caribbean and the United States. The unscheduled appearance of the boat was not the only unusual happening. In The Amistad lesson, students learn about these important historical events, and the influence of the Gulf Stream current on the path of the vessel.

Annually, before the onset of hurricane season, a drifting buoy array is deployed into waters of the tropical Atlantic. This array of drifting buoys provides weather forecasters with surface meteorological data in the region of hurricane development. Ocean weather data is usually collected by a network of commercial ships crossing the Atlantic. However, in times of rough seas or hurricanes, the commercial ships must deviate from their original course to protect the crew, ship, and cargo. The data collected from the buoys, combined with satellite data and information reported by special hurricane research aircraft, are used by meteorologists to predict the path of hurricanes. While engaged in the Drifters lesson, students will access the drifting buoy data base via the Internet. Students will:

- check that the buoys are still reporting data;
- monitor the various paths of the buoys;
- determine the influence of the Gulf Stream current on the drifters’ trajectories.

In the final Enrichment Lesson, Ship Movement in the Gulf Stream, students access near real-time velocity data for the Gulf Stream current. The students are then given various locations and ship headings to determine if the velocity of the current would create a noticeable difference to the resulting path of the ship.

C. Project Assessment

There are two lessons in the Gulf Stream Voyage project used for student assessment. The aforementioned concept map lesson contained in the Core Lessons, and the How Do Currents Affect You? lesson. In this lesson, students determine which current flows past the coast where they live and whether it is a cold or warm water current. The students are challenged to determine how they think the current affects their lives. Based on all of the information acquired in the unit, students must prepare a “Shore Guide.” The “Shore Guide” must contain information about the climate in the area, biological life found near the coast and the possibility of the water being warm for a beach outing.

IV. Evalutation

A. Purpose and Goals

In the spring of 2003, an evaluation of the Gulf Stream Voyage project was conducted. The purpose of the formative evaluation was to improve the Gulf Stream Voyage project educational materials and project Web site. During the evaluation, information was...
gathered about the use and usability of the educational materials and Web site by classroom teachers. The main questions for this formative evaluation were:

- How are teachers using the Gulf Stream Voyage?
- How can the Web site be improved?
- Do teachers understand real-time data?
- Are teachers using the real-time data?
- Are the lessons and other materials on the Web site supporting and enhancing what teachers do in the classroom?

B. Methods and Procedures

To gather the data needed to answer the evaluation questions, CIESE recruited middle and high school teachers to participate in the evaluation process. The teachers were asked to visit and review the project Web site, use the educational materials and project Web site with their students, and keep a journal of their experiences using the materials. Face-to-face interviews were conducted with three teachers and telephone interviews with seven teachers. Each interview consisted of:

- a discussion about the uses of the Web-based educational materials in the classroom by the teacher and his/her students;
- a review of any materials brought to the interview by the teachers;
- an assessment by the teachers of each of the features of the Web site to determine what teachers had used and what they liked/disliked.

Ten in-depth teacher interviews were the basis for the evaluation report. A small sample of evaluation questions and responses are contained in the following tables.

C. Evaluation Conclusions

Due to the wide range of student ability levels, prior science knowledge, and teacher competency levels, a wide range of responses were received on the use of the Gulf Stream Voyage project Web site. Generally, the middle and high school teachers were familiar with the science content and they were able to adapt and use the Web site as planned by the designers. Many, but not all, were able to keep their students on track. Overall, the participating teachers were enthused about the Gulf Stream Voyage project and were looking forward to using it during subsequent school years. Most of the middle and high school teachers were able to access the real-time data and solve the problems presented in the lessons (Parsons, 2003).

Evaluation of projects such as the Gulf Stream Voyage can not only improve educational content and lesson plans, but also begin to provide information as to how effectively or ineffectively students are using the data. Potentially, scientists and educators could share this information to improve both products.

V. Professional Development

Too often, computers have been provided for teachers with little or no associated training. Consequently, efforts to use or integrate computers in classrooms have been focused on simplistic uses such as drill and practice programs—a traditional use of computers, but not an effective or inquiry-based integration.

**Sample Interview Questions and Responses**

### TABLE 1
Responses to Question #12 (n=10)

<table>
<thead>
<tr>
<th>Question</th>
<th>Agreed</th>
<th>Disagreed</th>
<th>Undecided</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Web site provided lessons that I could use with my students.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>I found the Web site lessons easy to integrate into my curriculum.</td>
<td>90%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>I could have used more support on the use of the Web site.</td>
<td>10%</td>
<td>80%</td>
<td>10%</td>
</tr>
</tbody>
</table>

### TABLE 2
Responses to Question #13 (n=10)

**What did you like most about the Web site?**

The most common response (50%) was that the Web site used real-time data or had real-world applications.

“It made the Gulf Stream more tangible, that it has substance, and isn’t just a current of warm water. The site related the Gulf Stream to fishing, whaling, transportation, and made it more real; it’s not just a line on a map.”

“It’s on the Internet, easily accessible, you just click and go.”

“The activities are ready to go. Students just need a little bit of background/preparatory work. Also, the completeness of the lessons.”

“That it’s student-centered; they’re doing a lot of learning on their own, and I’m not teaching. They were interested, there was high student interest; it’s motivational for students.”

“The interdisciplinary nature of the site”.

“There are colorful pictures for visual learners”.

### TABLE 3
Responses to Question #14 (n=10)

<table>
<thead>
<tr>
<th>Question</th>
<th>AGreed</th>
<th>Disagreed</th>
<th>Undecided</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you like least about the Gulf Stream Voyage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40% mentioned that the data links were either too difficult to use or they did not work properly.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30% mentioned that the background information or the terms were difficult to find.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>30% mentioned that the questions on the worksheets were too open-ended.</td>
<td></td>
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</tbody>
</table>

### TABLE 4
Responses to Question #15 (n=10)

<table>
<thead>
<tr>
<th>Question</th>
<th>AGreed</th>
<th>Disagreed</th>
<th>Undecided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think you will use the Web site next year with students?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes – 90%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No – 10%</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
In an effort to improve educator understanding of the data, lessons and classroom implementation, more effective professional development opportunities, either face-to-face, online or a hybrid of the two, must be provided to teachers and other school officials.

In addition to curriculum development and promoting the use of Internet resources in K-12 science and mathematics education, CIESE offers professional development programs. When providing professional development for educators on the Gulf Stream Voyage or any other Internet-based classroom materials, we have found that it is important that:

- teachers experience the material just as the students would experience the material;
- the training should provide time for the teachers to become comfortable with the lessons and the data source;
- teachers should be given plenty of developed examples to use, augment and bring back to the classroom.

VI. Next Steps: Improvements to Data Display

Another component in the successful implementation of real-time data projects is the clarity with which technical information is represented on a Web site. The onus should not lie with potential users to decipher or interpret data, instead the scientific community should proactively create engaging, clear, and concise displays of data in an effort to reach non-scientific audiences such as educators, the general public, policy makers, resource managers, and the media. It is important that this data be accessible and understandable by users with a wide range of abilities, backgrounds, and prior knowledge.

The Gulf Stream Voyage is only one example of an educational application. As more real-time data becomes available to the public via the Internet, it will be extremely important to investigate and evolve a best practice methodology for the computerized display of scientific real-time data for consumption by the general public. This effort would not only begin to bridge communication gaps between scientific researchers and other audiences creating a more scientifically literate public, the information could trigger interest in the research and potentially open more funding pathways. Discussions of how to package data for multiple audiences should occur at the front end of the project by conducting audience needs assessments, and the discussion should include educators and members of potential user groups. Too often these discussions are tabled, resulting in situations where the creation of a more public-friendly display of data is considered too time consuming or expensive. If multiple user groups can work together from the beginning, this situation could most likely be avoided and potentially create innovative displays.

VII. Conclusion

The Internet is an important tool that teachers are using in classrooms all over the world. The integration of the Internet into classroom lessons promotes student engagement and encourages critical thinking, problem-solving, teamwork and increases self-motivated learning.

Providing access to real-time data activities presents opportunities for students to analyze and assimilate knowledge in a meaningful way. Educational research indicates that real-time data provides a greater sense of authenticity and purpose than textbooks or historical data sets. Using real-time data in classrooms engages students because they participate in the same scientific process as professional scientists.

The formative evaluation conducted on the lessons contained within the Gulf Stream Voyage project served as positive reinforcement of the benefits to using real-time data and technology in classrooms contained within educational research literature.

The Gulf Stream Voyage project is an example of a real-time data project that has been successfully implemented in classrooms. The use of formal evaluation of educational products is essential to assess the quality and usability of the materials. The results of the Gulf Stream Voyage formative evaluation justify increased usage of real-time data projects in classrooms.

Since the posting of real-time data on publicly accessible Web sites is prevalent within both the ocean science and commercial maritime communities (e.g. the proposed data streams from Integrated Ocean Observing System [IOOS] or data streams from IOOS or Ocean Research Interactive Observatory Networks/Ocean Observatories Initiative [ORION/OOI]), this subject matter is particularly appropriate for teaching through Internet-based classroom projects.

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References


