

Discussion of Results: Literature Review

We reviewed more than 25 peer-reviewed articles and evaluation reports to answer the question: What resources / models / products / projects currently provide classroom teachers with real-time observatory data? Which ones have been proven (evaluated) to work? The complete review is at <http://marine.rutgers.edu/outreach/rtd/>.

The key findings were:

- Lessons need to be flexible enough to adapt to user level, classroom time constraints and local phenomena, and be integrated into current teaching. Materials should be designed so that pieces can be removed and used by educators in other ways.
- Activities should encourage participation in multi-school communities (becoming a part of a larger community of science practitioners).
- Lessons should teach students why they are doing data collection and analysis, as well as what to do.
- Materials should be inquiry based, involve students in the full scientific process, and include hands-on activities.
- Lessons should be scaffolded so that at first there are more steps and guidance, but gradually they become more student-driven and open-ended.
- Visualization and modeling tools are essential to the development of RTD projects and they need to be specialized, refined or intermediary tools (different from those used by scientists) to support student learning.
- Teams that develop RTD lessons should be diverse and include expertise in science, technology, cognitive science, classroom teaching methods, and teacher professional development. Those partnerships should last long-term.
- Teachers are a critical link in the successful integration of RTD into the classroom curriculum, and so teacher preparedness, achieved through professional development, is essential.

Discussion of Results: Gap Analysis

The goals of this front-end evaluation were to:

- identify the gap between SWMP/IOOS scientific data (current and projected) and the needs/capabilities of K-12 teachers and students to use those data, and
- to determine and recommend ways to bridge that gap via data visualization/presentation and educational products/services.

The discussion in this section covers the first goal above (the Recommendations section that follows covers the second goal). A gap analysis (Weber, 1986) answers the questions: Where are we now? and Where do we want to be? Identifying any gaps will aid NOAA/NERRS in designing and developing an education product that successfully bridges what stakeholders wish to accomplish and what teachers can use. Analyzing the results from stakeholders and teachers have enabled us to identify the gap between the two views.

The main gap issues we explored using the results of this front-end evaluation are:

- target audience
- vision and goals
- content: data types / variables and sources
- product format & features
- barriers

Target Audience

There seems to be general agreement between stakeholders and teachers regarding the target audiences for this project, and they are:

- middle-school students and teachers
- high-school students and teachers.

(Reminder: This evaluation focused on K-12 classrooms. We recognize that college & university teachers and students, coastal decision-makers, the general public and informal education institutions are important audiences, but the goal here was to study one target group in depth, rather than studying many narrowly.)

The K-12 audience not included on this list is primary and elementary school students and teachers. This exclusion is not to suggest that younger students could not understand or their teachers could not teach using real-time data. We know they can and some teachers do. However, the types of data that would be made available through most ocean observing systems are less age / grade appropriate at this education level and students at this level are just learning the skills necessary to understand RTD. Given the limited resources of any project, it is important to focus and both stakeholders and teachers were focused on middle-school and high-school students for a RTD education product.

This study's results show a gap between stakeholders' views that high-school should be the primary target and teachers' and other data that indicate that middle-school would be the better primary target, especially for NERRS.

On the online survey, over 90% of respondents stated that high school (grades 9 – 12) should be the primary audience, whereas 56 to 76% stated middle school (6 – 8) should be the primary audience.

And although more high-school teachers attended the focus groups than middle-school teachers (56% vs. 43% respectively), in comparing the two groups' responses to the online survey we found that middle-school teachers were more likely to:

- have student use computers at school as part of their lessons
- have students use the Internet / websites at school as part of their lessons
- have students use real-time data (mostly student-collected data) as part of their lessons.

In addition, in the June 2003 report, *Inventory and Assessment of K-12 and Professional Teacher Development Programs in NERRS*, the most common audience was 6th to 8th grades (middle school) for both NERRS programs and teacher professional development. Thus there is already a wealth of experience among NERRS for working at the middle-school level.

A separate issue raised by a couple of stakeholders was how to accommodate under-served / under-represented students, such as minorities, ESL students, students in schools with limited access to technology, etc. They didn't want these students overlooked when discussing the audience for RTD education product(s).

Although the teachers who participated in our focus groups were for the most part White (we did not collect data on their race / ethnicity), their student populations were diverse: 57% taught in schools with mostly (60%+) White students, 17% in schools with nearly equal mixes of two or more ethnic / racial groups, 16% in schools with mostly (45%+) Hispanic students and 6% in schools with mostly (50%+) Black / African-American students.

During three of the focus group discussions teachers mentioned that some of their students had English language issues. In most groups teachers mentioned that they had a range of ability levels in their classes (we didn't ask specifically for those data). No one talked about any particular problems/issues with using RTD with diverse or special-needs students. Some stated that the act of collecting data actually helped these students, although equipment and computer availability was a resource issue for some schools. Based on these results, we believe RTD lessons could work with all students.

When we asked teachers to prioritize the features they would need in a RTD education product, features that would be especially useful for teachers working with diverse or special-needs students, such as Spanish-language worksheets or data-collecting kits, rated low on the list. Based on the results of this study we cannot answer the question of how to best meet the needs of these students and their teachers. That needs more study.

Vision & Goals

Interviewed stakeholders offered varied visions and goals on RTD in K-12 classrooms and for a RTD education product. From their statements there was no clear direction. Surveyed stakeholders were offered 11 goals (based on interviewee responses) and asked to choose what they thought should be the goal of education products based on RTD. Their top choices were:

- connecting students with real-world science (92%)
- improving inquiry skills (92%)
- better understanding of estuarine / coastal ocean research (72%)
- better knowledge of the environment (72%).

When asked to prioritize by choosing a primary goal, their top choices were:

- connecting students to real-world science (28%)
- improving inquiry skills (24%)
- improving ocean literacy (20%).

In all seven of the groups teachers talked about why they use RTD in their teaching, why it is important to them despite the many obstacles they encounter. The most often mentioned reason for using RTD was relevance—real-time data makes what happens in the classroom relevant to students' lives. It brings the real world into the classroom whether they're monitoring a schoolyard weather station, or testing and reporting on the water quality of a local pond, or tracking a hurricane. It also connects them to their future as citizens faced with questions requiring analysis in their roles as decision makers, voters, and possibly scientists. Connecting students to what's real was the main reason teachers use RTD in their lessons.

This "real world" connection chosen by stakeholders and as expressed by teachers should be a key part of the vision and goals for education products based on RTD.

Content: The Data

Data Types

As part of our gap analysis between stakeholders' views and teachers' views, we asked both groups about RTD data use in K-12 classrooms. For stakeholders this question was asked only of online respondents. We developed a list of 27 "data streams," largely based on the provisional IOOS core variables [pg. 20 in *First U.S. Integrated Ocean Observing System (IOOS) Development Plan*] available at http://www.ocean.us/documents/docs/IOOSDevPlan_low-res.pdf.

We asked stakeholders to indicate which data types they thought teachers are most likely to use and we asked teachers which data types they actually use. The table below compares rankings stakeholders views on what teachers would use compared to what teachers actually use (based on percentage and sorted by teacher use).

Data Types	<i>Stakeholders Ranking: Teachers Likely to Use</i>	<i>Teachers Ranking: What Teachers Use</i>
temperature: water	1	1
temperature: air	3	2
pH	11	3
salinity	2	4
dissolved oxygen (DO)	4	5
currents	9	6
water quality	7	7
algal blooms	10	7
animal tagging/tracking	5	8
video/live camera	7	8
zooplankton species	13	8
waves	14	9
ocean color	18	10
turbidity (clarity/cloudiness)	8	11
nutrients	9	11
fish species & abundance	6	14
river discharge	10	15

Some of the rankings of data types closely match, but there are also some clear differences between teachers' use and stakeholders' views. The design/development of a RTD education product should, at least initially, be based on the data types that teachers use, which will make their use of the product more likely.

Data Sources

An issue encountered during this study that surprised us was that of student-collected vs. scientist/observatory-collected data. On the teacher pre-workshop surveys, 61% of teachers said they use RTD from the Internet and 52% use student-collected RTD (these are tallies of responses to an open-ended question about RTD use in the classroom). When comparing middle-school teacher responses to those of high-school teachers, more middle-school teachers use student-collected data than Internet data (61% vs. 57% respectively), where the reverse was true for high-school teachers (64% Internet data vs. 45% student-collected data).

In all of the focus groups, teachers talked about having their students collect their own data, mostly weather data or water-quality data. For those teachers this introduced students to the concept of data (unfamiliar to many at the middle-school level), got them involved in something hands-on, connected them to their local environment and in some cases to the community, and engaged them in science as a process. Several teachers expressed that student-collected data combined real-time and relevance.

Another data-source question raised during this study was the issue of local data versus national or other data, which was discussed in five of the seven focus groups. Middle-school teachers, in particular, felt it was important for students to understand first what data are, then

become familiar with and understand local data. With that foundation, students could then use Internet-based local or national data for baseline or cross-site comparisons, for understanding broader systemwide concepts and issues, and/or for investigating issues that they can't investigate locally.

If NERRS is to focus on the middle-school audience initially, it's in the perfect position to provide teachers and students with opportunities for collecting data locally as well as offering local and national data sets for comparison. Whatever data types/streams or data source(s) become the basis of a RTD education product, it was clear from teachers' conversations with us that the data be relevant to their students, either to their lives (personal or virtual lives) or the communities in which they live.

Product Format & Features

Stakeholders and teachers offered many of the same suggestions for the features of an idea RTD education product. Based on our conversations during this study we developed a list of nearly 40 features consistently mentioned by both groups (*see the full report for the complete list*). During two prioritization sessions with stakeholders and teachers (one at a COSEE-Mid-Atlantic teacher meeting and the other at an MBARI EARTH summer teacher workshop), we were able to develop an "essentials" list.

The top features chosen by stakeholders were (not in any hierarchical order and presented as worded for the prioritization activity):

- data visualization tools (ability to graph, map, chart data)
- downloadable to Excel or other spreadsheet
- inquiry-based lessons/activities for students
- lesson plans for teaching science concepts with real-time data
- local [locally relevant] data sets
- map interface so you can find where real-time data is collected
- online [web] access to data sets
- real-time data projects for students
- stories or case studies that show how scientists use real-time data.

The top features common to both middle- and high-school teachers were (not in any hierarchical order):

- data visualization tools (ability to graph, map, chart data)
- downloadable to Excel or other spreadsheet
- lesson plans for teaching science concepts with real-time data
- local [locally relevant] data sets
- map interface so you can find where real-time data is collected
- tips on how to get started using real-time data in classroom with students.

Note: Features chosen differed somewhat depending on the grade level (see pages 57 & 58 for lists by grade level from elementary school through college).

For the most part, top features chosen by teachers matched those chosen by stakeholders. Because these choices were in the abstract, that is, based on a list rather than a real product, we asked focus group teachers to review two RTD websites as models and provide feedback regarding what worked and what didn't about each.

Neither website met all their needs, although the Eyes on the Bay website was more positively reviewed as being closer to what they were looking for than the CDMO website. Generally, the features that met their needs/ desires were:

- page layouts that were simple, not too cluttered, with few words
- lots of visually based explanations (illustrations, pictures, graphics) and data visualizations, but simple in design
- local data sets (viewed as relevant) that could also be compared to places nationwide
- good easy-to-access explanations of content, parameters and terms
- intuitive navigation in and out
- data that's easy to get to—just a couple of clicks
- ease, flexibility when comparing data parameters
- easy to download data to Excel
- access to tabular data as well as data visualizations.

Design of the RTD education product should incorporate these features and those from the prioritization list at a minimum.

In all focus group discussions teachers talked about their limited time to teach all that's required and the limited time of a class period. To help them better manage their time they requested simplicity in design, limited text and lots of visuals (for quick absorption of information), quick and easy access to data, and lesson plans to teach concepts and/or interpret the data. The majority of teachers were fine with an Internet-based product as long as they could download data for teaching if they couldn't access the data when needed or for students to be able to manipulate. Very few teachers requested that RTD be provided on a CD or in print materials.

There were mixed views regarding the target (and therefore the design) of the online education product—should it be designed for teachers or for students? A few teachers wanted to be able to send their students directly to the site; others did not. Teachers offered no clear guidance on this issue. It seems to be a personal preference and/or depend on students' abilities.

An issue that was not available on either website but which came up in the focus group discussions was the need for different entry points for different levels of learners—from introductory (what is data?) to advanced (how to use of data and what they mean). These multiple levels were appropriate for teachers and students. Teachers requested two to three entry levels, clearly identified as such.

During five of the focus groups teachers talked about connecting students with scientists. They were mostly interested in getting answers to questions, especially regarding what the data mean. However, during the prioritization sessions, this was not among the features in the “essential” category.

During the stakeholder interviews and online survey, several people mentioned the importance of viewing this product as part of a whole program that includes, ideally, all of the following:

- data collection at NERRS or other sites local to schools
- data use in the classroom (the RTD education product)
- training of classroom teachers: pre-service training, in-services, ongoing support
- training of NERRS Education Coordinators (ECs) on the use of RTD in NERRS education programs and on working with classroom teachers to help them integrate RTD into their teaching. *Note: training for ECs in teacher professional development was a recommendation in the June 2003 Inventory report cited earlier.*

Barriers & Challenges

Both stakeholders and teachers held similar views on the most common barriers and challenges. The primary barriers expressed by stakeholders were:

- funding/ costs
- time
- developing an effective product and presenting data so that they're useful
- teachers' abilities and available time
- student access to technology
- testing/standards
- RTD viewed as an add-on, not integrated
- no clear vision for this product

In almost all of the seven focus groups teachers mentioned testing and standards, in particular state standards. Most teachers agreed that lessons/activities aligned with national standards are not helpful; teachers need some way (keys, tables, etc.) to know how lessons/activities meet their particular state standards.

Further results from this study illustrated that this issue of standards/testing is actually the greatest barrier to a RTD education product. From our "Where do RTD fit?" activity during the focus group sessions, teachers showed us the disconnect between the potential for RTD in exciting students and teachers and connecting them to the real world vs. the reality of today's K-12 teaching environment with state standards and high-stakes testing.

On the RTD lesson planning/teaching process maps teachers indicated overwhelmingly that RTD must fit with (listed hierarchically):

- student interest (indicated on the map by 96%)
- science inquiry (94%)
- current events and science concepts (both 92%)
- student skills/science skills (88%)
- math skills (81%).

RTD did not fit as well with

- state standards (indicated on the map with 53%)
- curriculum & textbooks (43%)
- state tests (22%).

These results were for RTD that teachers are currently using. When we asked them to map SWMP/IOOS data, they fared even worse on those three items:

- state standards (indicated on the map with 43%)
- curriculum & textbooks (33%)
- state tests (15%).

And although teachers are acutely aware of standards and testing, many of the ones we talked to were passionate about using RTD to connect students with the world around them and so used creative ways to align the use of RTD with their standards/testing-based teaching.

Given the realities of high-stakes testing (National Research Council, 1999), any RTD product needs to be designed to support what teachers currently have to teach/test and be integrated into what they do instead of as an add-on. In addition, if NOAA scientists and educators view RTD as the future for science, there needs to be work on the political front with science education reform to make changes in what teachers are required to teach/test and how they teach so what they do matches how science is conducted.