



# “Caution, this will NOT be on the test!” Expedition Earth Science Prepares Students for the 21st Century

## SUMMARY

Expedition Earth Science takes students on motivating journeys where they explore the natural world through an approach that emphasizes both the process and the development of problem-solving skills. The authors explain how collaboration, literacy, interpersonal skills, and content knowledge can be taught in a real world context and adapted by others in various settings.

### *On a Saturday afternoon,*

knee-deep in tea-colored lake water, Olivia and Riley pull and tug on the seine net as they drag it to the shoreline to see what they have caught.

The seine net, an aquatic survey tool, is loaded with leaves, small fish, and creatures from the bottom of the lake. It is the critters from the muddy and sandy bottom the girls are hunting. They are surveying the lake bottom for invertebrates that occupy the base of the food web and are often hard to find. The girls laugh and their eyes open wide when they see what they have caught. While the girls are pulling their net onto the shore, other student groups are collecting and identifying ferns, testing the water chemistry of the lake, drilling tree-ring cores to study climate patterns and tree growth,



*Riley (left) and Olivia pull a 20-foot seine net from a lake in central New York.*

and mapping the bottom of a smaller lake. Make no mistake ... this is school and the students have chosen to take on these credit-bearing tasks!

*Jeff Peneston teaches earth science at Liverpool High School. Peneston is the 2011 New York State Teacher of the Year. Andrew Calderwood teaches earth science at Liverpool High School.*

**Jeff Peneston, United Liverpool Faculty Association**  
**Andrew Calderwood, United Liverpool Faculty Association**

*“At first I was surprised to find anything in the net, and then I was anxious about getting bitten! Ultimately I was excited to hold all of the small, living things.”*  
— Olivia Sherwin

Olivia and Riley, along with the other 18 students that weekend, were participating in Expedition Earth Science (EES), an experiential education program designed to provide authentic learning experiences for ninth-grade earth science students at the Liverpool High School Annex, located in central New York. For participating in an expedition, students earn earth science lab credits toward the 1,200 minutes required by New York state and up to five points of extra credit on their quarterly grade.

More important, on the weekend expeditions, students learn many skills that are not measured on standardized tests. They collaborate in small teams, practice “just in time” learning as they work with new and unfamiliar scientific equipment (like the seine net), build resilience as weather conditions change and equipment fails, and, in the end, they also gather authentic scientific field data through creative problem-solving.

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## Expedition Earth Science

The Expedition Earth Science program, designed in 2000, was established based on the following goals:

- **increase** the rate and retention of inquiry-based **scientific learning**;
- **enhance** student interest in **science throughout high school**;
- **encourage** students to pursue **science/engineering careers**;
- **act** as a **test** of an instructional model that could be applied to other courses;
- **foster** the use of existing **district technology**, such as laptop computers, data collection hardware and software, and online research services; and
- **develop** collaborative **relationships** with local businesses, agencies and science professionals.

Parental support for transportation and adult supervision during the expeditions are key to the success of the program. Involving parents gives them the opportunity to be a part of the child’s educational experience and fosters a feeling of ownership in the educational system. Expeditions take place on evenings and weekends so that our time in the field does not impact other content areas or the students’ weekday schedule. The EES program involves small teams of students working cooperatively to ask questions, solve problems, gather data, and report on their findings.

Seven to 10 expeditions are offered throughout the school year from October to May, giving each student an opportunity to be involved no matter what their schedule is like. About half of the expeditions cost the student nothing and the others range up to \$65. There is no organized fundraising, and families choose what they can afford. Each expedition begins at an after-school meeting about two weeks before the trip, where the students form teams and receive detailed assignments describing the problems that they must solve by collecting scientific data in the field on the day of the expedition. Students are expected to create a finished product (reports, displays, presentations, etc.) from their experience. Expeditions typically consist of 15-24 students, two teachers and up to 10 parent volunteers.

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Students need to explore the real world through experiential education, using teamwork, research, and critical thinking.

### EES Rationale

Students today will become the parents, employees, leaders, and voters who will inherit and lead this country with scientific literacy. They are the generation that is increasingly expected to prove themselves through performance on tests even though they have a decreasing experience with authentic scientific problem-solving.

Unfortunately, these students have less contact with the natural world than any generation before them. Dhanapal & Lim (2013) report findings that have proven, “. . . that indoor and outdoor learning complement each other in improving students’ academic performance and have also showed positive responses among the students in choosing outdoors (rather) than indoors for learning science.”

Educators at all levels need to be encouraged and supported to engage students in authentic problem-solving. Students need to explore the real world through experiential education, using teamwork, research and critical thinking.

*“Expedition Earth Science . . . changed my life. I experienced firsthand what science is and how it works in places I never imagined.” — Mark Alessi, Cornell University, meteorology major*

Experiencing real work environments and solving authentic problems is a very old and extremely powerful teaching/learning paradigm. Educators in today’s classroom are working to lead students through demanding curricula, but they generally hesitate to utilize this oldest of approaches to learning. “Hands-on” has become a term that is often trivialized and overused by educators. We can also fail to see how a one-inch cube of rock or a satellite image of an approaching storm pales in comparison to the on-site experiences that real scientists have when exploring a geologic field location or working outdoors during the storm. Many aspects of science education are very poorly attempted in the best of classrooms. Students find it difficult to become enthusiastic about careers in science when their exposure to the exciting nature of those careers is limited to traditional teaching methods (Larmer and Mergendoller, 2010).

*“Before this experience I had never considered a career in science, but this helped me realize I could potentially have a career that combined my passion for the outdoors with problem-solving.”  
— Sara Coffey, University of Hawaii, geochemistry graduate student*

The EES program provides an intimate learning environment where students are provided the opportunity to select a task or problem of their choice and collaborate with one or two other students. In this way, students are practicing critical thinking and problem-solving skills for 21st century learning.

### **21st Century Skills**

While education in the last century often focused on content-driven curricular objectives, we all know that in this digital age, the content of our world is largely available to the literate. The 21st century will require people to gather, process, and produce their own content and solutions (Trilling and Fadel, 2009). Our current students will become the adult citizens of the future and the research describes the types of skills we need to help them develop. In the broadest context, we want our students to have the power to choose educational and career trajectories that will interest them and enrich their lives. As a society, we will need our students to become the problem-solvers who are experienced at working collaboratively in groups with the interpersonal skills and resiliency to complete complex tasks as a team. They will also need to be adults who know how to find and use authoritative sources of

information (literacy/research tools). We also know (Larmer and Mergendoller, 2010) that adults in the 21st century will need to be able to use those sources of information and their own creativity to generate original approaches to accomplishing the tasks of life.

The EES program is less concerned with the traditional content knowledge and emphasizes the processes of problem-solving and the development of these skills. EES starts by allowing students to select an outdoor expedition and a research problem that interests them. Next, students form teams and learn about their project goal through meetings and background research. The teams travel to field locations to collect specimens, data, or to perform a task. Finally, they practice literacy skills as they create a final product or presentation that they can share with others. Throughout most expeditions, we expect the authentic nature of field science to provide the teams with unexpected problems from equipment malfunctions and weather challenges, to opportunities to experience unplanned events and discover things that were unexpected. We joke with our students that the subtitle to the Expedition Earth Science program is “caution, this will NOT be on the test!” and we admit that few of the lessons learned will directly transfer to the high-stakes, year-end exam. But,

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we also know that the summative evaluations that await them in their adult lives will draw heavily from the skills developed on our expeditions.

*“I’ve always been a ‘hands-on learner’, so this experience was beneficial to me because I realized a career where I could be doing vs. reading would be beneficial to me.”*  
— Sara Coffey

**Collaboration** — Student groups meet prior to the expedition so the teams can research their chosen task and prepare themselves for the remote, outdoor field locations. They share ideas, make a plan for their research, take down notes, and print information sheets relevant to their area of research. This may include identification charts or directions for how to use equipment. Students may also spend time practicing the use of the actual equipment. During the trip students must work together to collect data in the field, paddle canoes, adjust to complications, or create presentations to communicate their work to an audience. Following an expedition, students meet during or after school hours to produce their expedition product, which for some trips include professional quality displays, short videos, or essays. For each one of these steps (before, during, and after the expedition) the team must communicate and work together to achieve their goal.

**Authentic Setting** — One goal of EES is to place students in authentic situations and locations where they feel their work mirrors what might take place in the real world. The use of authentic equipment and procedures is also crucial to the integrity of the program. For example, two of the expeditions on our annual list are collaborations with Hobart and William Smith Colleges (HWS) in Geneva, NY, where our students travel out onto Seneca Lake and work on a 65-foot research vessel owned by the colleges. The professional-quality equipment they use on those days allows them to collect data on the lake sediments, water chemistry, and planktonic life that become part of a growing database used by the scientists in the Geosciences Department at HWS.

*“I learned new things about the lake but also about being a scientist in the real world. The use of different instruments to collect data was a way to apply what we learned in class, expanding our knowledge about science.”* — Megan Corcoran, SUNY University at Buffalo, geology major

Through grants and awards over the years, we have also been able to purchase a variety of professional scientific tools for our students to use that rarely would be included in high school

science programs. We have rock-cutting saws, environmental chemistry testing kits, and even an underwater video camera that we use to explore the depths of area lakes.

*“...standing on Rams Head on the Island of St. John in the USVI...I observed unrelenting 30 mph winds and direct sunlight which helped me to understand why Rams Head has a desert microclimate.” — Mark Alessi*

**Literacy** — One of the foundational principles of the EES program is that the expeditions would not be a “passive visit” where we tried to walk “everyone” through an experience. We chose to limit the number of students on each expedition so there is the intimacy to allow student teams to work with the teachers. Each student team is required to create a finished product in order to qualify for course credit. Our goal is to have the students create documents that reflect what real scientists are paid to produce: Data summaries for a local college, slide shows to share with others, documentary videos, museum displays, and even live webcasts all require students to practice literacy skills at a high level. Examples of some of these videos and a student-created blog can be accessed at <http://teacherpages.liverpool.k12.ny.us/webpages/jpeneston/index.cfm>



**Interpersonal Skills** — Typically, classroom teachers attempt to design activities in which all of the tools and steps are provided to the students and the teacher has the maximum control of the process and the outcome. The

*The image at the top is a micrograph taken by a student. The watercolor artwork below was created by that student as part of a museum display.*

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teacher is also the one who is expected to help students overcome procedural problems. All of this can lead to correct answers and good grades, but it fails to reflect that most of the problem-solving in our adult lives is fraught with unexpected problems and the expectation that we have to rely on our teammates more than our employers. Students on EES adventures cannot complete the process or project without working in teams. Listening, sharing, leading, collaborating, and being flexible are as important as scientific knowledge. On some expeditions, students also get to practice living with

other students and their teachers at our weekend and weeklong field camps. Learning to live with neighbors who snore and teachers who can cook chocolate chip pancakes are all part of the EES experience.

*“One of my friends who I had just met in earth science freshman year became my best friend during the trip and still is like a sister to me today. We laugh at the memories made on the trip. The expeditions not only helped expand students’ knowledge of science but also foster relationships from the experiences shared on the trips.” — Megan Corcoran*

**Resilience** — Teachers usually know the answers and are sure of the methods before they ask the students to attempt an assignment, and this leads students to believe that real science begins with a worksheet, 10 guaranteed steps and the equipment already set up in the lab.

Authentic scientific research often requires scientists to invest the majority of their time in the development and validation of data collection methods. Field scientists must be able to prepare and react to every type of mechanical breakdown and change in the research plan once they are in the field. EES encourages students to pursue questions that are beyond their teacher’s knowledge and use original procedures. This often leads to discovery but it usually leads to things going wrong in the field. Students are encouraged to imagine every possible contingency before the trip and then the student teams are expected to solve the problems mid-stream.

*“After months of planning to measure the differences in salt water salinity, we arrived on St. John and found that our salinity meter would not work. We had to quickly find a new topic and get ready to report our findings on the live webcast.”— Alex Moore, 12th grader, Liverpool High School*

### Measurable Outcomes

In 2012, as part of a graduate course, Calderwood conducted primary research on the EES program. The question under study was: What, if any, impact does the EES program have on students’ perceptions and attitudes regarding science? The study utilized a pre survey given to 180 students in eight earth science classes. The questionnaire encompassed 26 questions broken down into six sections. The six sections of the survey asked the students to identify their current academic level in earth science and if they had signed up for an expedition, their perceptions of science education, rank order words describing how science is delivered to them, complete a science favorableness scale, answer Likert-type questions dealing with perceptions of science process skills, and complete an open-ended question about their single best science moment.

The post survey was similar to the pre survey except where it asked the respondent to identify which expedition they attended, their comfort level prior to and after the experience, and an open-ended question asking them to describe their experience. The results were gathered in both qualitative and quantitative form. In summary, the data showed that:

- 69 percent of students signed up for at least one EES out-of-school, experiential education experience.
- The predominant reasons described by students for attending these expeditions included the fact that they were “real-world,” “fun,” “new,” or “outside.” These are often conditions not associated with school, where most learning takes place at a desk within the four walls of a classroom. Because the students see the EES program as a novel educational program, and because research has shown that the brain seeks out that which is novel, EES is very successful at drawing in students to the program.
- The data seem to indicate that students move from an impression of science being fun in elementary, to interesting in middle school, to an expectation of interesting (but also

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stressful) in high school. Also, the data showed that the anticipated stress level associated with science dropped from 30 percent prior to an expedition to 12 percent following an expedition. This may signify the building of resilience in students who attended EES trips.

- Students also listed “real-life,” “outdoors,” and “field trip” as the least teacher-utilized aspect of their science education. The EES program fills this gap for those students interested in this type of educational learning approach.
- The Thurston method of measuring favorableness resulted in academic students scoring 5.25 out of 7 (1 least favorable and 7 most favorable) and honors students scoring 5.70 out of 7. What was most interesting, however, was that students who attended an EES experience were still just as favorable to science but at a much higher frequency (for example, 84 percent agreeing on a statement for the pre survey, but 100 percent agreeing on the same statement on the post survey). The data suggests that there seems to be a strong relationship between attending an EES experience and students’ positive view of science.

- The post survey also indicates that students are much more confident with the process of science following an experience with the EES program (29 percent of students self-selected as confident in the pre survey and that number increased to 52 percent following an EES trip).
- Finally, the open-ended question regarding “How would you describe your experience in terms of how this trip impacted your view or attitude about science” resulted in answers such as: “. . . would like to go on another trip,” “more interested in science,” “do it again in a heart beat,” and “trip increased my already positive view on science.”

Since students ranked the EES trips as highly scientific (8.8 to 9.3 out of 10), and with the sense that their perception and attitude regarding science was made more positive through an EES experience, it appears the EES program does not just supply a fun event for students to attend, but a meaningful learning experience.

### Transferring the Model

*Bryce and Liana are both elementary-aged students who have come along on an expedition to a salt mine in central*

*New York where 380 million year-old rocks are exposed. They have joined an EES trip to this location, north of Ithaca, NY, with about 20 ninth-grade students, a dozen parents, and three teachers to excavate, collect, identify, and build displays for the fossils of ancient sea life that can be picked from the quarry here. Excitement and surprise light up their faces with each new discovery. However, this trip has a twist. The third teacher on this expedition is an art teacher who works with the students after they have collected their fossils to refine their scientific drawing skills. This particular trip is a hybrid of sorts, mixing two very different and seemingly unrelated content areas — earth science and art.*

Although this program is called Expedition Earth Science, we have always imagined it as a pedagogical model that was adaptable and transferable to other subject areas and age groups. Clearly, teachers in other high school science content areas can find value in field science but we know that teachers of literacy, art, history, languages other than English, and cultural studies would enjoy all of the benefits of this model as well. We have our students engage in literacy skills such as journaling and video production and have found that outdoor environments are great settings for encouraging those activities. Since most of our expeditions encourage



*Above, parents work alongside students on a fossil dig site.*



*At left, Liana looks up from a 375 million year-old sea floor where she has been finding her fossil trilobites.*

parents and the occasional siblings to participate, we have the experience to show that this type of outdoor experiential learning works for multiple age groups from pre-K to grandparent.

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More than  
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EES prepares  
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generation.

To date, more than 2,000 students and parents have taken part in the EES program. After 14 years and more than 120 expeditions, this approach to science education has repeatedly proven to benefit the earth science students involved, but it has also suggested unlimited opportunities for similar programs across grade levels and subject areas.

More than delivering content, EES prepares students beyond the three R's and helps them to become the effective communicators and creative problem-solvers of the next generation.

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