Inquiry-based Science for All

If there is one word that New Hampshire teachers have heard most since the N.H. Frameworks for Science Literacy were revised in 2006 and NECAP began testing in 2008, it is “inquiry.” Though only one of the process skills that all students should be practiced in, inquiry is the essence of the nature of science. It is important to know that there are essential components to inquiry, as well as different levels of engaging in inquiry with students. Not all inquiry is chaotic; some forms have a more structured approach (see sidebar on page 2).

To ensure that science literacy is achievable, every student should have exposure and practice with inquiry at all levels. Like inquiry, all process skills must be practiced often and at all levels in order for students to be able to apply them to varying degrees of scientific information and thinking. We hope this issue of Project WEB will provide you with examples and strategies to better engage your students in inquiry and the science process skills.

“Inquirize” Your Hands-on Science

“Science is a way of trying not to fool yourself.”

—from lecture
What Is and What Should Be the Role of Scientific Culture in Modern Society,
given at the Galileo Symposium, in Italy, 1964.

Many people believe that any hands-on activity can be considered “inquiry.” However, inquiry doesn’t happen without an investigable, or explorable, question and the gathering of data or evidence that can be used to think critically about what is observed. If students are given materials and the step-by-step instructions to make their own miniature water cycle, for example, they are doing a hands-on activity, but not necessarily inquiry. They have received the materials and the process to follow without being asked to THINK about what they are doing, consider what question they are answering, or even support new questions that may arise. A more inquiry-based approach to this activity might be to let the students determine on their own how to create a visible water cycle using only the materials provided. Then ask them whether or not it was successful, why or why not, and how this model could be improved.

Bringing inquiry into your classroom does

Students discover the properties of water through small group investigations.

by Alicia Carlson, N.H. Project WET Coordinator

PHOTO © N.H. PROJECT WET
You don't need to spend a lot of time looking for new activities...begin to alter your current lessons to be more inquiry-based.

The Inquiry Continuum

- Confirmation Inquiry: Students confirm a principle through an activity when the results are known in advance.
- Structured Inquiry: Students investigate a teacher-presented question through a prescribed procedure.
- Guided Inquiry: Students investigate a teacher-presented question using designed/selected procedures.
- Open Inquiry: Students investigate questions that are student formulated through student designed/selected procedure.

– from “The Many Levels of Inquiry,” by Heather Banchi and Randy Bell

5 Essential Components of Inquiry

- Students are engaged in a question.
- Students give priority to evidence.
- Students develop explanations based on evidence.
- Students evaluate their explanations in light of alternative explanations.
- Students communicate their explanations.

– National Research Council, 2000

Activities Related to Articles in this Issue

Project WET Suggests:

In the activity, Is There Water on Zork?, middle school students describe the qualities that distinguish water from other clear liquids, design an investigation to test the characteristics of water, and analyze the efficiency and effectiveness of the investigation.

Students observe how groundwater transports pollutants and simulate groundwater testing to discover the source of contamination in The Pucker Effect.

In Cold Cash in the Icebox, elementary students design mini-insulators (iceboxes) in an attempt to keep ice from melting, compare the insulating properties of various materials, and discover the challenges of refrigeration of 100 years ago.

Project WILD suggests:

Elementary students have a chance to sharpen their observation skills in Learning to Look, Looking to See. They first practice observing in a familiar indoor setting, then go outdoors to try their new skills in a different, unfamiliar setting.

In Bird Song Survey, high school students inventory songbird populations by investigating a specific area, identifying birds that are present by their songs, and recording their observations.

In the WILD Aquatic activity, Water Canaries, middle school students investigate a stream or pond and determine water quality by using a variety of sampling equipment to collect macro-invertebrates, then identify them.

PLT suggests:

In the activity Sunlight and Shades of Green, students use their inferring skills as they are introduced to the process of photosynthesis by investigating what happens to leaves when they are blocked from sunlight.

Students practice their critical thinking skills in the activity In the Driver’s Seat. They track their family’s transportation for a week and explore the complex energy issues that are involved.

In People of the Forest, students compare and contrast different forest peoples, both past and present, as they discover how humans have relied on forests throughout history.
New Hampshire Education and Environment Team (NHEET)

Supporting the teaching of science through the use of the natural environment

In 2002, projects Learning Tree, WET, WILD and HOME, the GLOBE Program and the US Forest Service’s Conservation Education program created an alliance called the New Hampshire Education and Environment Team (NHEET). The national curricula-based projects and programs of the alliance support the teaching of science through the use of the natural environment and environmental issues and encourage teachers to take their students outdoors for experiential learning.

The alliance was created to increase the impact and reach of individual member’s programs through collaboration and a pooling of resources. By working together through NHEET, higher levels of content and concept integration can be achieved, extending each of the program’s missions and benefiting educators, administrators and, ultimately, students statewide.

Currently NHEET is making a difference in New Hampshire by working with teams of teacher mentors from six districts to increase the vertical science literacy of their schools. Teachers are guided through a process to vertically align their K-12 curricula with the NH Frameworks for Science Literacy and encouraged to embrace inquiry-based science teaching that incorporates data collection and field investigations. The effort is made possible by the support of federal Math and Science Partnership (MSP) grants administered through the New Hampshire Department of Education.

Other NHEET accomplishments include joint publicity and workshops, an annual week-long summer workshop for teachers and the development of scope and sequence models for building vertical science literacy.

For information about how to get your school considered for involvement in an upcoming Math Science Partnership Program, contact NHPLT at 603-226-0160 or info@nhplt.org.

Become a Learner – Engage Your Students

by Carol Cohen

Raingear mandatory – laptops optional. WHAT? This is what I read the first time I signed up for an inquiry-based science workshop. I am a veteran elementary teacher who has taught science using books, kits and weekly readers, trying to explore the best I knew how. I put much time and energy into setting up learning stations, but didn’t feel like I was always engaging my students. So, I did what every good teacher would do – I became the LEARNER.

Since embracing inquiry, I have rediscovered the FUN part of teaching – the light bulbs going on and the excited “aha”! We have planted in the greenhouse to grow a salad, collected data on when the leaves finally fall from the trees, checked to see what conditions melt snow fastest, and hunted for signs of animal tracks in the snow. I discovered that children have questions that are answered by DOING. They think “outside the box” and are able to make predictions, solve problems, try different things and imagine how to change their approach to make it better. I have applied process skills and now find these hidden science words are everywhere!

• Classify – We compare stories in literature.
• Observe – We find common patterns in math.
• Share results – We graph, make maps, create tables in math and social studies.
• Interpret data – We organize our facts to better understand a story.
• Draw conclusions – We get to the main idea.

With these results happening in science, why don’t we get off the stage and engage our children as learners across the curriculum? Check back with me next year and I will tell you; I am on it!

Carol Cohen is a grade one teacher and science teacher mentor at Ellis Elementary School in Fremont, N.H.
Using Inquiry Every Day

By Jan McLaughlin

What tools can we use to encourage students to understand how science works? Science learning should include frequent, rich and engaging activities that are relevant to both the student and the community. To put ideas about inquiry into an accessible format, science specialists from the New England Common Assessment Program (NECAP) states developed The Guidelines for Development of Inquiry Tasks (GDITS). Originally designed to help develop inquiry tasks for the NECAP Science Assessment, this document can serve as a blueprint for helping students understand how science, as an enterprise, functions.

The GDITS lay out thirteen inquiry constructs and divide those among four broad areas of inquiry that students need to experience: Formulating Questions and Hypothesizing; Planning and Critiquing Investigations (and research); Conducting Investigations (and research); and Developing and Evaluating Explanations. The GDITS can serve as a framework to make sure that activities move students along a “learning progression” in inquiry. They are not meant to be the only source of ideas for including inquiry in schools and science centers.

In the GDITS, each broad area of inquiry is addressed in a separate section. Each broad area is further divided to be age appropriate for specific grade spans (4 = grades K-4, 8 = grades 5-8, and 11 = High School). New material for a grade span is underlined.

The GDITS can be found on the N.H. Department of Education website at www.education.nh.gov.

Using the GDITS

The GDITS can be used in small ways to help students understand a specific area (construct) of inquiry. Perhaps you want all students to show mastery of data collection and organization (construct 8). What data will students collect every day for a specific period of time? How will they organize that data? Can you provide different experiences for students to explore ways of collecting data and organizing information (graphic organizers, tables, etc.)? Over time and with repeated practice, students will develop a sense of what organizing tools can best be used for different types of information.

To get the most from GDITS, focus on a larger activity to occur over a number or days, weeks, throughout a season or for the year. Use the GDITS to help you plan the Inquiry steps for an investigation or field research with students. What will you study? How will you study it? What data or information will your students gather? How will they share the information with others?

Traditionally, students are taught science as if it is a language arts activity. Students read a chapter from a text and then follow with definitions and answering questions in the back of the book. While these tactics may help students understand basic terms and concepts, they do not convey “how science, as an enterprise, functions.” Without this key understanding of the foundation of science, students will never fully understand how scientific concepts have shaped our understanding of the world.

Jan McLaughlin spent 8 years as the N.H. Science Education Consultant, was part of the NECAP Science Team, and now works independently on professional development and curriculum projects on local, state and national levels. She can be reached at janmc@comcast.net.

Observations vs. Inferences

Teaching students to make inferences means showing them how to use their careful observations and use them to explain natural phenomena. Looking at wildlife “sign” (clues animals leave behind) is a great way to engage students in investigating the difference between observations and inferences. Since we seldom see the animal itself when we are outside, we make observations of the sign and then use this information to make inferences about who left it behind.

Spring 2010 WEB Resources

- Outdoor Inquiries: Taking Science Investigations Outside the Classroom by Patricia McGlashan and Kristen Gasser; Peter Dow, David Hartney, Bill Rogers Heinemann. Portsmouth, N.H.
- Teaching the Nature of Science through Process Skills: Activities for Grades 3-8 by Randy L. Bell; Pearson Education, Inc., Boston
- Field Investigation Models: www.nhplt.org/resources
  – Field Investigation Guide
  – Show Me a Picture, Tell Me a Story: An Introduction to Graphs for the Analysis of Ecological Data from Schoolyard Science Research Studies: Harvard Forest Schoolyard Ecology Program Harvard Forest, Petersham, MA.
Using N.H. Data Sets and Field Investigations with Students

By Dr. Judith Silverberg
N.H. Fish and Game

Three important components of the scientific inquiry process are the ability to represent data, analyze the results of an investigation and communicate the findings using evidence for support. Teachers have a diversity of science data they can access and use. The Great Backyard Bird Count and Journey North are just two of many national investigation programs that invite students from all states to participate and provide data online.

Whether you are looking at scientists’ field investigations or your own, always start with a question—an “investigable” one. Try to use questions that are descriptive, comparative or correlative (see page 7 for a free online Field Investigation Guide). Students should always master investigating descriptive questions first. Descriptive investigations involve describing and/or quantifying parts of natural systems. Comparative investigations involve collecting data on different populations or organisms, or under different conditions. Correlative investigations involve measuring or observing two variables and searching for relationships (see page 7.)

The next step is to determine how to represent the collected data. Students can use diagrams, flow charts, tables, bar graphs, line graphs, scatter plots or histograms to identify patterns and relationships in the data. Use mathematical analysis to examine the data – means, modes, medians, t-values or r values, as appropriate. Since analysis and communication come later in the scientific inquiry process, the time required to do a thorough job and reinforce these skills in the classroom may be limited.

One way to give your students more practice with these more involved skills is to have them use data sets. Using data that has already been collected allows teachers to focus students on the critical thinking parts of inquiry. The N.H. Education and Environment Team (NHEET) has prepared several N.H. data sets appropriate for middle and high school students. Each data set includes a “Data Info Sheet” that contains the research question used, how the data set is used by scientists, raw data (presented in Excel spreadsheets), examples of data analysis and graphs, sample analysis questions to be used with students and additional resources.

Data set topics include minimum-maximum temperature data and precipitation data from the 1950s to today (collected at the U.S. Forest Service Hubbard Brook Experimental Forest in Woodstock, N.H.) and Winter Severity Index (WSI) data collected for the N.H. Fish and Game Department by participating N.H. schools from 2002-2008. These data sets are available for download at www.nhplt.org.

In the end, it is important to re-visit the original question. Does the data answer the investigative question? How do the data/results support or refute the question? What new questions do you have? When students have finished with this portion of the science process, they should be able to provide a clear conclusive statement that answers the investigative question, as well as be able to ask new questions and recommend future actions.

Students Data Skills Help Document
N.H. Winter Deer Survival

Winter, Weather and White-tailed Deer is a wildlife management curriculum unit that provides middle school students with an opportunity to practice science process skills like collecting data and becoming involved in real-life wildlife management. By measuring daily temperatures and snow depths between December 1 and April 30, students gather crucial data used by N.H. Fish and Game biologists in determining the annual Winter Severity Index (WSI). The WSI is used to estimate the effects of cold, snowy winter conditions on New Hampshire’s deer populations.

Winter severity is measured using a system that involves keeping track of the number of days when the minimum temperature is 0 degrees Fahrenheit or less and/or when the snow depth is 18 inches or more. Deer are not able to meet their daily nutritional requirements during the winter and must rely on stored fat for their survival. Whenever the temperature is very cold and snow is deep, deer tap into their fat reserves for the extra energy they need to keep warm and move about. The WSI gives biologists a good estimate of the number of deer that will survive the winter.

If you would like to involve your class in collecting data for the WSI, contact Mary Goodyear at mary.goodyear@wildlife.nh.gov or 603-271-6649 by early October. Fish and Game provides participating teachers with a thermometer and a snow stake to install on their school grounds, as well as a copy of the related curriculum. Data sets from previous years are available for student analysis and integration in the curriculum.
First Grades Incorporate Process Skills into Curriculum

By Shannon DeRosa and Doug Kilmister, Pittsfield Elementary School

Teachers at Pittsfield Elementary School are rewriting several of their science curriculum units to include science process standards, and they are beginning to use the new Atlas Curriculum Mapping software to organize and align science units so that content and process skill standards are addressed in a powerful sequence of learning.

One of the units included in Pittsfield’s curriculum map is a first-grade science unit entitled Senses. Teachers Kelly Marble, Karen Eade, Shannon DeRosa and Jeanne Howard wrote the unit this spring. The unit’s kickoff activity begins with reading the big book Being a Scientist published by Newbridge. Then the entire first grade takes a trip outside to conduct a field investigation using the school’s nature trail. The essential questions students will explore:

• How do we gather information using our senses?
• How do our senses help us to learn from each other?
• How do our senses help keep us safe?
• What can help us gather more information than our senses can alone?

The Senses unit was created in response to our district’s initiative to engage students’ learning in more effective ways through the use of science process skills. Process skills that are targeted in the unit include making observations, asking questions, exploring, investigating, sorting and classifying. During this unit, students read to learn about human senses. They then explore using their senses to describe various objects. Students use a variety of scientific tools – such as a magnifying glass, balance, thermometer, ruler, scale and microscope – to gather first-hand observational information about things in their environment.

Pittsfield teachers believe that engaging students in science process skills early will contribute to future learning and engagement with content. They believe that curriculum mapping will give them the vision to help students reach high standards and help teachers plan effectively. It has already encouraged a great deal of conversation among the teaching staff.

ANNOUNCEMENTS

Watershed Ecology Institute

Two-week course (Monday through Friday) offered July 19-July 30, from 8:30 a.m. to 3:30 p.m. at Plymouth Regional High School. Undergraduate and graduate-level summer program geared to science educators and community leaders. Coordinated by staff from N.H. Fish and Game, the course offers techniques for applying science in real-world situations. Each day, specialists focus on a different aspect of watershed ecology using hands-on, experiential learning. Can be taken for 2 credits from the UNH Division of Continuing Education. Contact Judy Tumosa, at 603-271-3212 or judy.tumosa@wildlife.nh.gov.

PLT Releases Environmental Experiences for Early Childhood

PLT’s new early childhood guide integrates nature-based exploration, art, literature, math, music and movement, and outdoor play into early childhood education programs. The guide contains eleven activities that encourage young children to explore the senses, the seasons, and neighborhood trees. The activities highlight the importance of kinetic learning and engagement by incorporating music and movement using an accompanying music CD. Contact info@nhplt.org for more details or to set up a workshop.

2010 New England Environmental Educators Conference

Reserve the weekend of October 21-23, 2010, for the Annual New England Environmental Education Alliance conference at Lake Morey Resort in Fairlee, Vt.: Create, Cultivate, Collaborate: Designing Our Shared Future. The event is merging with the Promise of Place Conference and is bringing together a wide circle of people who in their work or recreation, connect people with the environment. Visit www.neeea.org.

N.H. Science Teacher Association (NHSTA) Fall Conference

This conference for both teachers of science and science teachers will be held at the Attitash Grand Summit Hotel on October 24-25, 2010. Go to www.nhsta.net for more information.

Introducing PLT’s New Online Community!

Join PLT’s New Online Community for Educators at http://connect.plt.org. There you can access the PLT Biotechnology and Biodiversity Lesson Plans; discuss issues; share ideas and success stories; send updates to colleagues; join and form groups related to professional development topics; and chat with educators from around the world. The PLT Online Community is a community of learners and professionals aided by online resources – much like a Facebook for PLTers. This connection will help you strengthen your use of PLT and improve student learning. We look forward to chatting with you online!
Bringing Back the Butterflies
"Kids for Karners" Dives into Inquiry

by Marilyn Wyzga

For the past 10 years, schoolchildren in Concord, N.H., have been helping to restore an endangered species to a globally rare ecosystem (see the fall 2009 issue of Project WEB for background story). "Kids for Karners" involves local children in hands-on restoration of the endangered Karner blue butterfly (our State Butterfly) through the propagation and planting of wild blue lupine and other native flowers, increasing the available host plants and nectar sources in Concord's remaining pine barrens plant community. Karner restoration provides a wealth of educational opportunities; it teams professional biologists with students and addresses a genuine environmental issue involving ongoing field investigations that help teach the process of science through inquiry.

More than 600 children and youth in more than 25 classrooms have each cared for their own wild blue lupine plants and transplanted thousands of seedlings onto the pine barrens. As the wildflower seedlings grow in the classroom, students learn about butterfly ecology and life cycles, the important relationship between Karner blues and their host plants, the ecology of the Concord Pine Barrens and the concepts of endangered species, habitat and conservation.

“Kids for Karners” engages students in grades pre-K through 9. Because the focus is a single school district, some students have gone through the annual planting process more than once. Yet the experience stays fresh as each grade correlates the planting and restoration effort with specific grade-appropriate units (ranging from native N.H. wildlife, to plant growth, endangered species, insects and pollinators, and climate change). Each year, the staff aligns this project with the current Concord Schools curriculum and the relevant state frameworks, then structures a professional development training for participating teachers.

Real-life Science

N.H. Fish and Game Department wildlife biologists Heidi Holman and Lindsay Webb bring in the real-life science. During the teacher training, they explain field investigations they are conducting with the Karners, which serve as models for the teachers to facilitate inquiry-based science and field investigations with their own students. In addition to their field work, during the course of the 10-year project, the Karner biologists have continued to investigate the best conditions for plant propagation success. They have experimented with and altered the planting medium, seed preparation, planting containers, base materials and the transplant dates.

Holman and Webb have organized their current field investigations by the three types of investigable questions, framing them with examples of guiding questions:

Descriptive (what, when, where, etc.):
- How many lupine stems are there in a given location?
- What is the Karner blue butterfly’s geographic range?

Comparative (compares two factors or features):
- Is there a difference in the type of moth species found in a forest habitat versus a grassland habitat?
- Is there a difference in the Karner blues’ genetic makeup between populations in Albany, N.Y., and Concord, N.H.?

Correlative (correlates factors, investigates the action of one factor on another):
- How does female fecundity (number of eggs laid) change as the timing of habitat management changes?
- Does larvae growth rate change as temperature changes?

Participating teachers learn that finding out how many lupine stems there are in a given location involves a two-week, multi-person effort, using a straight counting of lupine stems in the field along a 50-meter tape transect; that a light trap is used to compare moth species in grassland, shrubland, and woodlands within the pine barrens restoration area; and that Karner female fecundity helps determine if there is a preferred time for burning or mowing the site.

Incorporating Inquiry

Modeling the biologists’ investigations, “Kids for Karners” teachers have incorporated inquiry into their part of the project, the planting of the lupine and nectar...
plants such as New Jersey tea, blunt-leaved milkweed and yarrow. They have guided their students in experimenting with planting media, planting containers, lighting, temperature, watering and coverings for the planters. As the seeds germinate and grow in their classrooms, the students observe and measure growth, collect and analyze data, and report out their results to N.H. Fish and Game. They describe plant growth on their tracking sheets, compare different lighting or watering schedules, and correlate multiple variables such as temperature and substrate. Elementary students focus more on the science process skills, while the middle and high school students (both 9th grade biology classes and the Advance Program) engage in more complex investigations and with a higher level of content. Students construct much of their knowledge, coming up with questions and trying to answer them through investigations, to arrive at conclusions.

“Kids for Karners” classrooms consider these kinds of investigative questions:

**Descriptive:**
- How many (or what percentage of) lupine seeds germinate?
- What does a lupine plant need to grow?

**Comparative:**
- Is there a difference in growth rate between the plants placed on the windowsill and those away from the window?
- What has greater planting success – the lupine or nectar plants?

**Correlative:**
- How does the plant medium change the germination rate of the seed?
- Does plant growth rate change as temperature changes?

As they carry out these inquiry-based investigations, they are employing science process skills, such as: Making observations and asking questions (SPS1.1), designing scientific investigations (SPS1.2), conducting investigations (SPS1.3), and, in the 7th and 9th grade classes, evaluating scientific explanations (SPS1.5). They also collaborate in these scientific endeavors (SPS3.1), teaming up to plant within their classrooms and across grades; this year, the 9th graders initiated a “Bio Buddies” partnership with two second-grade classrooms. This builds interpersonal, collaborative and communication skills, as well as critical thinking and creative problem-solving skills.

While this particular restoration project is unique to the Concord School District, every school can plant to attract and provide habitat for local, native butterflies and other pollinators and engage in inquiry-based field investigations right in their own schoolyards. For more information, contact N.H. Fish and Game Wildlife Educator Marilyn Wyzga at marilyn.wyzga@wildlife.nh.gov or 603-271-1197.

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