General Use Guide

How can students better understand our dynamic Earth system? How can students effectively observe and collect data about the Earth system? What defines “local” observations and how can students meaningfully extrapolate their data to a larger ecosystem or the entire Earth system?

Overview

The **3-d Quadrat Program (3-d QP)** is designed to encourage students to actively explore their environment by looking closely at a well defined natural space. Data collected using one-cubic meter quadrats define an inclusive open natural laboratory and are designed to help students understand the very dynamic and, multifaceted, and complex Earth system and many of its interconnected chemical and physical components.

The one-cubic meter frames are constructed of sturdy, simple, inexpensive materials, and adaptable enough to be placed in any environment. Components measured in each 3-d quadrat include aspects of all five spheres of the Earth system: atmosphere, biosphere, hydrosphere, lithosphere, and cryosphere. The 3-d Quadrats create a workable-sized space that encourages close study of all these interactive parts of the Earth system. The frames can be placed on the ground, partly on the ground and in water, or completely submerged. Once in place, additional 3-d Quadrats can be linked to observe multiple specific environments and relationships between them.

The basic unit of measure in the 3-d QP is $1m^{3--}$although we encourage teachers to create multiples of this size. The 3-d Quadrat Program enhances analysis of the ecosystem and provides a more realistic and inclusive design for understanding the complete Earth system. By focusing on 3-d spaces, students are better able to understand the interactions of the entire Earth system. 3-d quadrats include cross sections of the atmospheric, the subsurface, and chemical, biological, and physical cycling.

3-d Quadrats in use from Maine to Montana.

Grade Level

K-12

Objectives

In the 3-d QP students will:

1. Learn that the atmosphere, biosphere, hydrosphere, lithosphere and cryosphere are interconnected.
2. Understand the number and complexity of components operating within the Earth system.
3. Learn careful observation skills.
4. Understand how observations collected in a local area can be linked to adjacent areas, and extrapolated to a larger area such as the globe.
5. Identify their own place on the planet and their ability to interact within and influence the natural systems on the Earth.

Materials

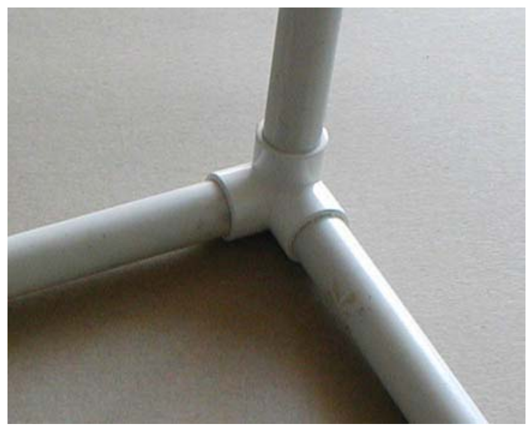
1. 12 -94cm long PVC tubes

   The 6 extra cm will be added by the corners, making each side exactly 100cm or 1 m long. PVC is light, strong, and easy to work with, but wood or metal can be substituted. Varieties of recycled plastic tubing are also available. Although any diameter of tubing works, the 1” tubing is sturdy enough for any outdoor application (and available at most hardware stores). Tubing usually comes in 10’ sections, so you will need a saw to cut it to length.

PVC tubing cut to 96 cm lengths from the original 10' tube.

2. 8 PVC corner pieces to connect the PVC tubing
   from greenhouse supply companies
   (http://www.littlegreenhouse.com/accessory/pvc.shtml)

PVC corner piece.



Corner piece with tubes inserted.

3. Plastic sheeting and or $1m^2$ plywood pieces.

4. Plastic ties (or string) to connect plastic sheeting, plywood, and/or instruments.

5. Tether (possibly a chain) to secure your 3-d quadrat in place
   Add stakes to prevent it from being moved and disturbing your study site.

A ¼ sized 3-d Quadrat (25 cm) per side) tethered to a sea wall on Cape Cod, Massachusetts.

6. Instruments appropriate to your topic of study.

The best in technology or the simplest instruments can be used or made to measure various Earth system parameters. For example, wind speed can be measured with a digital data logger that records wind speed continuously over a specified amount of time and easily downloads into your computer. Or you can use the "golfer" method and simply sprinkle some grass clippings in the air and use the direction and angle at which they drop to determine wind speed and direction. The former is done automatically and provides more data. The latter is still effective and gives students a "hands-on" understanding of what data is being collected.

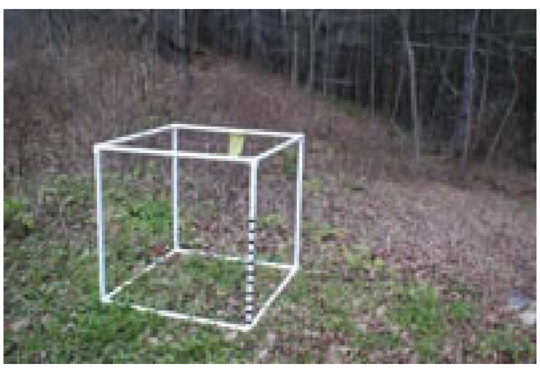
Your students need to measure at least two parameters so they can later compare the data and explore how those parameters may be related. Other variables should be added over time but this will increase the difficulty in understanding dependent components. The fewer the parameters measured, the easier it is to monitor effectively and discover patterns.

Teacher Preparation

Gather materials and then build, or have students build, your 3-d Quadrats. The standard 3-d quadrat is a $1m^3$ frame made of PVC tubing, wood, metal, or any material. The teacher or the students should then select "permanent" locations in which to place their 3-d quadrats. Depending on your planned use, you may not need to glue your 3-d quadrat pieces together. A non-glued 3-d quadrat is still very sturdy, might be left in place for years, and still be easily disassembled.

http://www.tufts.edu/as/wright_center/3dqp/image_gallery.html

The more permanent the location the longer the data set that can be collected. An on-going location not only will allow students to analyze data from within a single collection season, but over longer periods, as data collected by different groups creates a growing data base. Once your materials are collected it takes about 20 minutes to build a 3-d quadrat.



A 3-d quadrat in place in the Maine.

Site Selection

Any outdoor site is a good site for a 3-d quadrat. Consider a location where your 3-d quadrat will not be disturbed, a place where you can secure it to prevent it from being moved. Most 3-d quadrats left alone will stay in place with a simple tether.

http://www.tufts.edu/as/wright_center/iecws/images/iecws_photo_gallery/cryo_2007/cryo_2007_slideshow_2/Dynamic/index3.html

The location you select depends largely on what you want to emphasize in your observations and data collection. If you want to focus on ground vegetation and its connection to the rest of the Earth system, then you should place your 3-d quadrat in a field/yard. If you want to focus on the connection of water and land then you should place your level 3-d quadrat partially in the water and partially on land.

Not every cubic meter of the Earth has all the exact same components and your focus will help determine site selection, but every cubic meter of Earth is ultimately connected to every other cubic meter and thus every 3-d quadrat is connected to every other. As your focus changes you may want to consider building additional 3-d quadrats and through observation, learn the connections between them. A very common method of studying a large area is to set up a *transect*, along which you place multiple 3-d quadrats. This gives you a detailed look at specific geographic areas across a larger geographic area.

Time Frame

Quadrats can be used for a single unit, or for a year-long study. The longer the period, the greater the variety of data student will collect. How frequently students collect data from the quadrat can also vary, but we recommend using it as often as possible. A single class might gather data at the same time(s) each day, while a teacher with multiple classes could have students in each class record observations, allowing students to look a change within a single day

Teaching Sequence

Once a 3-d Quadrat is in place it can be used for years for a variety of studies. Observations can be made for science, literature (journaling – reading) math, art, geography, or any number of other disciplines. The 3-d quadrat serves as a window to a small confined space as well as a window from a small space to the larger environment.

How you use the 3-d quadrat depends on your classroom objective. The 3-d quadrat then defines the space where any number of scientific “experiments” takes place. Examples of variables that students can observe or measure easily include temperature (air, soil, water), wind speed and direction, and precipitation. A more extensive list of variables, instruments and links is included in the 3DQPinstruments.xls file.

Observations should be collected in units that are age appropriate. One benefit of using a 3-d quadrat is that it works as an open system: physical and chemical components such as temperature and moisture move in and out of the 3-d quadrat space. Nearly all of the parameters that operate in the Earth system operate in a 3-d quadrat, and this is true for almost any location you select for your quadrat.

The best way to begin an experiment with your 3-d quadrat is to select two parameters from any of the Earth spheres (cryosphere, lithosphere, hydrosphere, biosphere, atmosphere). For example, you might measure the interaction between temperature and light intensity. As the light intensity increases during the day it can be measured by simple visual estimates or by any number of instruments such as photo-sensitive paper, light intensity meters, or data loggers. At the same time you would also measure temperature with a thermometer or data logger. Students can then compare these two data sets over the same period and determine the relationship between light intensity and temperature.

Measurements can be taken at different places within the 3-d quadrat, depending on your goals. In computer modeling, measurements are made in the center of a grid space (cube) to represent the value for the entire space. If your goal is to measure the temperature difference between ground level and 1m above ground level-- showing changes in temperature as the ground heats first during the day-- then take your measurements on the ground and at the top of the cube.

As new observations are made, measurements can be taken on other parameters such as wind, soil moisture, barometric pressure etc. The relationship between each of these can then be determined.

An additional benefit of the $1m^3$ 3-d quadrat is that, unlike outside natural conditions alone, it can serve as a testing laboratory. For example, you can add additional moisture into the system and to test how it affects another parameter such as temperature or light intensity. You can also close up the sides of the 3-d quadrat to eliminate or intensify different parameters. A "roof" can be attached to the top of the 3-d quadrat to shade areas within. This change may affect temperature, evaporation (moisture concentration), etc. Or sides can be attached with plastic wrap to allow sunlight to move through but shelter the interior from the wind. A bottom might eliminate biological productivity and or moisture evaporated from the ground. The open system can then become a closed or partly closed system. In this way students can measure and test Earth system components all in the same location while eliminating errors.

Since we can't see many of the parameters that can be measured within the 3-d quadrat, a tutorial for visualizing these data has been devised – see visualizations.

Making observations/Collecting data

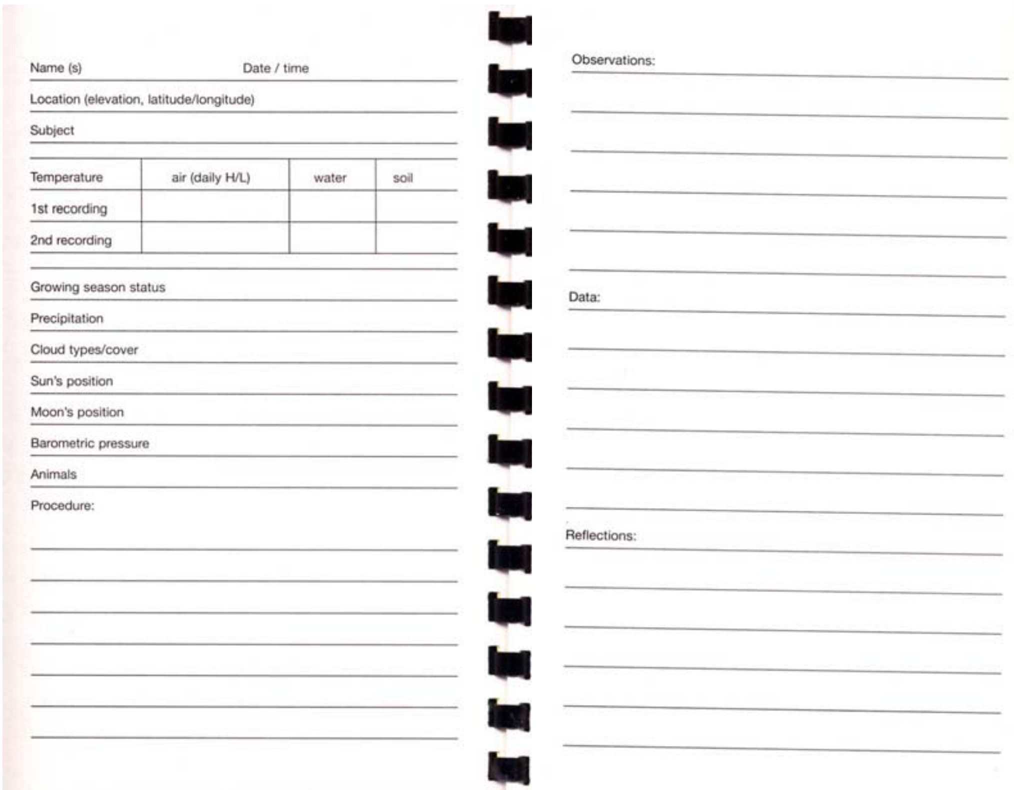
Whenever possible, students should make and record observations using all five senses, with or without additional instruments.. There are many methods to instruct students on collecting and recording observations.

An example of a fun way to make observations using all five senses fun is to do a Haiku Journey (http://www.tufts.edu/as/wright_center/iecws/materials_teacher_dev.html). A Haiku Journey allows students the opportunity to make observations focusing on one sense at a time and then encourages them to record that sensation as a Haiku. A Sensory Journey can also be accomplished using any method of recording the observations, from poetry to sketches to narratives or labels.

Journals

We suggest that you make your students' journals age appropriate and start with simple narratives and sketches in nature type journals. For a video narrative on one type of journaling – Sketching with Lines and Words, see http://www.tufts.edu/as/wright_center/3dqp/videos.html

There are also many types of nature journals and many ways to record information in them. Whichever method you use, make it consistent for all students each year. Consistent methods of collecting data make it easy to make comparisons within the class and among years of observations. Use any format for journaling that you prefer though we suggest using preformatted journals or notebooks to remind students of the types of observations they should be collecting. A sample list of relevant observations is shown below This list can be preprinted into journals for student use.



Name (s) Date / time

Location (elevation, latitude/longitude)

Subject

Temperature	air (daily H/L)	water	soil
1st recording			
2nd recording			

Growing season status

Precipitation

Cloud types/cover

Sun's position

Moon's position

Barometric pressure

Animals

Procedure:

Observations:

Data:

Reflections:

Formatted journal

As your class becomes adept at making observations they may want to extend their observational abilities by using instruments. There are as many kinds of instruments as there are things to observe. Many can be built from scratch and cost very little; some, such as data loggers, are more complicated and can be expensive. Instruments vary from those that require direct user involvement and can collect only one data point at a time to those that can log data remotely and be downloaded to a computer after a specified amount of time.

A partial list of observations, the instruments used to collect them, and a web resource that may be useful for making those measurements can be found in Appendix A. (There was no appendix listed)

Elaboration

Applications for using a 3-d quadratcross grades and disciplines. The quadrats can define a space that can be used to observe and collect data as well as define a space that might be used to assign responsibility or ownership. If every person on the planet was responsible for just 1 m^3 of the Earth it might encourage better stewardship of the Earth's resources. 3-d quadrats can also create a space that might geographically define where each person is on the planet, possibly how they fit into the big picture, possibly both geophysically and possibly philosophically. It can be the one place that belongs to an individual and the piece that connects you to everything else.

Exchange

A forum to exchange 3-d QP ideas has been established at http://www.tufts.edu/as/wright_center/3dqp/. Teachers or students are welcome to post new ideas and comments. Please send all forum exchanges to wright_center@tufts.edu

Evaluation-Questions

1. Is the 3-d quadrat easy to construct?
2. How did the 3-d quadrat help you define the area in which you collect observations and data?
3. Is the shape and size of a $1m^3$ quadrat easy to expand or contract to work within the principles of multiples of ten and basic size and scale?
4. How many different types of measurements were you able to make within your 3-d 3uadrat?
5. How many times were you able to make observations and collect data? Was it sufficient to see a trend?
6. Can your observations and data be linked to other data sets you collect to see a longer trend?
7. How many different parameters are potentially interacting inside your 3-d quadrat?
8. Are the data from individual 3-d quadrats easily linked?
9. Can the data from a 3-d quadrat be extrapolated to "observe" a larger set of the Earth system?

General resources/and for making weather instruments
(also see the spreadsheet in Appendix A)

Franklin Institute Resources for Science Learning
http://www.fi.edu/weather/todo/todo.html
Making observations
http://www.the-private-eye.com/index.html

Glossary
3-d Quadrat- Frame made of various materials constructed into a 1m3 cube. Used as an open laboratory to observe and experiment on Earth systems.

Barometric Pressure - the pressure exerted by the Earth's atmosphere at any given point, being the product of the mass of the atmospheric column of the unit area above the given point and of the gravitational acceleration at the given point. (dictionary.com)

Quadrat- a square or rectangular plot of land marked off for the study of plants and animals.

Relative Humidity - the amount of water vapor in the air, expressed as a percentage of the maximum amount that the air could hold at the given temperature; the ratio of the actual water vapor pressure to the saturation vapor pressure. Abbreviation: RH, rh (dictionary.com)

Soil moisture – A measure of the amount of water in the soil. Soil moisture can be estimated by feel and appearance of the soil.

Temperature - a measure of the warmth or coldness of an object or substance with reference to some standard value. The temperature of two systems is the same when the systems are in thermal equilibrium. dictionary.com)

Transect - A transect is a path along which one records and counts occurrences of the phenomenon of study (e.g. animals, for instance by noting each in (http://en.wikipedia.org).

Velocity - rapidity of motion or operation; swiftness; speed: a high wind velocity (dictionary.com)

National Standards
Content Standards K-4
Content Standard A:
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B:
- Motions and forces
- Transfer of energy

Content Standards C:
- Characteristics of organisms
- Life cycle of organisms
- Organisms and environments

Content Standard D:
- Properties of Earth materials
- Objects in the sky
- Changes in Earth and sky

Content Standards E:
- Abilities to distinguish between natural objects and objects made by humans
- Abilities of technological design
- Understanding about science and technology

Content Standards F:
- Changes in environment

Content Standards G:
- Science as a human endeavor

Content Standards 5-8
Content Standard A:
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B:
- Motions and forces

- Transfer of energy

Content Standard C:
- Populations and ecosystems
- Diversity and adaptation of organisms

Content Standard D:
- Structure of Earth system
- Earth’s history
- Earth in Solar system

Content Standard F:
- Populations, resources, and environments
- Science and technology in society

Content Standards 9-12

Content Standard A:
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B:
- Interactions of energy and matter

Content Standard C:
- Interdependence of organisms
- Matter, energy, and organization in living systems

Content Standard D:
- Energy in the Earth system
- Geochemical cycles
- Origin and evolution of the Earth system

Content Standard F:
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national and global challenges

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