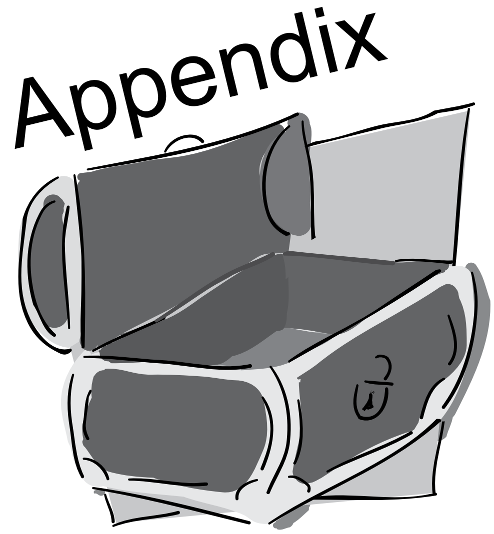


Education Materials and Information

Science Materials and Information

Education Information

Using GLOBE to Teach Literacy and Language Skills

Working with Literacy and Language Learners Around the World

GLOBE is the means to create an enrichment program that actively enhances the academic achievements of the entire student body, ultimately integrating literacy skills in reading and writing with all disciplines in the school. Science integration into the language classroom provides a rich context for genuine language usage. Literacy skill development can be enhanced using GLOBE storybooks that highlight scientific protocol areas and integrate grade appropriate inquiry-based science activities into school curricula. Many teachers are incorporating GLOBE activities into projects that require independent research and report writing, critical thinking, problem solving and data collection. Students can simply read a book or they can combine reading with hands-on, minds-on investigation and really gain an understanding of the literature. Reading about water quality doesn't really hit home until students have also had the chance to visit the riverbank, perform tests on the water and record data in their field notebooks! Creative writing activities such as Haiku, an easy form of poetry, can also be used later in the classroom to describe their findings and explore new vocabulary.

Content-based foreign language programs focus on enhancing and reinforcing the regular curriculum through a diverse combination of lessons that include learning activities in content areas spread across the curriculum. Many foreign language teachers have begun to weave interdisciplinary lessons into their everyday classroom teaching in order to provide their students with authentic learning situations that promote communicative competence. Using the GLOBE Program, foreign language teachers can easily integrate science, mathematics, technology, social studies, culture and language into the classroom.

Research has shown that students in programs that utilize interdisciplinary, content-based instruction make language gains equal or superior to those in traditional classrooms; learn large amounts of subject matter in less time; develop more positive attitudes toward the target language they study because it is presented in a meaningful context; show increased self-confidence in their ability to use the target language; and express an interest in pursuing its study.

GLOBE activities and materials facilitate second language acquisition through content-based lessons and GLOBE effectively incorporates all five goal areas (communication, cultures, connections, comparisons, communities) of the *National Standards in Foreign Language Project* (1996).[1] GLOBE students are introduced to other languages and cultures as they engage in authentic projects and meaningful discussions with one another, students in other countries, and world experts in the disciplines they are studying. GLOBE activities allow students to relate second language lessons to familiar subjects and experiences through personal involvement in the classroom activities and topics studied. Students reinforce and further their knowledge of math, science, social studies and technology through the foreign language as they measure, calculate, report and enter data on the Internet. Students also have a means to engage in conversational exchanges with their peers in other countries who are conducting the same scientific *Protocols* in their classrooms through their teachers; teachers can "friend" others within the GLOBE community. Because GLOBE is a worldwide program, materials will be available in multiple languages whenever feasible, such as the six United Nations' languages (English, Spanish, French, Russian, Chinese, and Arabic). Additional languages may become available through our international partners. GLOBE introduces students to other languages and cultures as they engage in authentic projects and meaningful discussions with one another, students in other countries, and world experts in the disciplines they are studying. The GLOBE Program provides a unique, hands-on setting for content-based K-12 language study through the age-appropriate educational materials and learning activities that promote civic competence consistent with the National Social Studies Standards (2000).[ii]

GLOBE is currently being used in a variety of ways to promote literacy skills around the world. In countries where students are required to learn English as their second language, schools are using GLOBE materials written in English. In the United States, GLOBE is a means of content-based language instruction in many languages. GLOBE is also being used as a means to teach English to students who are deaf or hard of hearing. These students' first language is American Sign Language (ASL), but through GLOBE they switch to English text to read and write—the knowledge required to participate in online discussions. The examples above demonstrate many different ways that The GLOBE Program, when used to supplement the school's curriculum, assists teachers to bring collaboration into the classroom to address the literacy needs of all students.

Working with English Language Learners in the United States (ELLs)

GLOBE provides teachers the opportunity to assist English Language Learners (ELLs) to acquire English literacy skills in the regular classroom while learning the curriculum outlined for their respective grade levels. ELL students also assume leadership positions when discussions and Internet exchanges related to GLOBE occur with other students from their home countries. GLOBE provides ELL students access to high-quality science information that can be presented, as needed, in their native first language. Participating in GLOBE program activities promotes active development of Basic Interpersonal Communication Skills (BICS) as well as Cognitive Academic Language Proficiency (CALP). GLOBE activities and materials facilitate English language acquisition through content-based lessons and GLOBE effectively incorporates the *ESL Standards for Pre-K-12 Students* (1997)[iii], acknowledging the central role of language in the understanding and achievement of content knowledge.

New figures released in January 2003 by the Census Bureau reported that the Hispanic population in the United States, the nation's largest minority group, is now roughly at 17 percent (July 2012). GLOBE is a means to create an enrichment program that actively includes the Hispanic student population in a school while enhancing the academic achievement of the entire student body, ultimately integrating literacy skills in reading and writing with all disciplines in the school.

In regard to teaching ELLs, teachers should employ the same teaching strategies used with the rest of the class, maintain high grade-level expectations, set a challenging pace for covering the curriculum, provide students with content and resources written in their native language as needed, and employ basic teaching practices that work with all students. Additional suggestions include:

1. Learn as much as possible about each student's culture and background in order to establish direct connections with the existing knowledge (generally culturally based) that each learner brings to the task at hand.
2. Allow parents and community members to contribute to and be included in the instructional process of ELLs.
3. Place students into flexible learning groups and utilize tiered assignments, employing multiple cueing modes to relay information.
4. Create an instructional program that provides abundant and diverse opportunities for listening, speaking, reading and writing while utilizing a variety of different teaching methods.
5. Incorporate reading materials that stress cultural diversity and positive aspects of the various cultures of the world, including aspects directly related to the student.
6. Set appropriate linguistic demands so that learners are capable of making full use of the verbal skills they possess and are able to build upon these skills.
7. Provide clear, understandable instructions for student activities and use visual aides, model expected behavior, and provide learners with appropriate ways of asking for

clarification if they do not understand.

8. Help students negotiate meaning by using modified speech, providing visual support, and planned meaningful redundancy of content (in the student's native language if needed).
9. Provide students with discussion periods or rehearsal time before each questioning session. Use different types of questions for checking for understanding and increase wait time after questioning.
10. Use multiple measures for assessing and evaluating their work. Aim instruction slightly above the students' existing level.

Alternative Teaching Strategies

Following are 10 strategies that teachers can use to create a flourishing and successful learning environment for GLOBE activities.

Strategy 1

Enhance comfort levels in the classroom.

Teachers can modify their classroom environments to meet the learning style preferences of their students. For example, GLOBE-focused *instructional centers* can be created to separate students who focus better when classroom stimuli are removed. Other students may need softened illumination for better concentration, while others learn best within an informal seating structure or when music is played in the background. Teachers may also permit students to have healthy snacks when students get hungry and stray from tasks on hand.

Strategy 2

Introduce new materials through one modality (e.g., reading drawing) and then change the modality for the reinforcement portion of the lesson.

For example, if you introduce the GLOBE *Hydrosphere Investigation* materials by providing details, further activities must help learners make connections with the *big picture* of why this information is important. The reverse is also true. If you introduce the GLOBE Hydrosphere materials by talking about relevance – general issues with water quality—make certain that following discussions focus on the issue in the local environment for reinforcement.

Learners also need to apply what they have learned.

- Analyze, synthesize, compare, contrast, draw hypotheses, expand information
- Students convert what they learned into new instructional resources to use or share with classmates such as,
  - creating crossword puzzles using terms from the GLOBE *Hydrosphere Investigation* area
  - designing a flip chart showing water cycle
  - writing a story about a local issue and how it was handled through use of GLOBE data

Strategy 3

Use whole class discussions to follow the introduction of topics and for the reinforcement of ideas.

Teachers can lead whole class discussions that engage their classes in open or targeted dialogue about materials just introduced or an activity already conducted. Whole class discussion is effective only when students critically evaluate preconceived ideas, notions and relationships about specific topics. Research has also found that small group work and individual practice followed by whole class discussions improve student achievement.

Whole class discussions can also be effective diagnostic tools for determining the depth of students' understanding and identifying students' misconceptions. Teachers can identify areas of difficulty for particular students, as well as ascertaining areas of success and progress for others.

When leading whole class discussions, the teacher's role is as a facilitator, guiding students through an exchange and sharing of ideas. Teachers should not use questions to direct discussions, but rather to prompt and guide students as they change their preconceived ideas and notions.

A teacher may decide to introduce a Soils unit through a cooperative learning format such as *Think-Pair-Share* (described in greater detail in one of the sample Soils lesson plans included in the previous section). Students think about what they already know about soil and discuss its importance within their groups of two. Once they have completed this small group activity, the teacher assembles the whole class to discuss soil and its importance as an introductory lesson to a month-long unit on soils.

Strategy 4

Use group work.

Cooperative learning activities allow students to help and support their peers in a group while boosting their achievement. Students practice interpersonal skills while achieving academic goals. Through group work, students encourage each other to critically evaluate new and difficult information. Cooperative learning groups can be used at any stage of learning, whether introducing a topic or reinforcing learned concepts. Students in cooperative learning groups can conduct almost all of the GLOBE *Protocols* and *Learning Activities*. How to construct and manage these groups is explained in the following section.

Strategy 5

Allow processing time between the introduction of new materials and the reinforcement of learned concepts.

Teachers should plan lessons and activities with time for students to process new concepts and ideas. Students need time to reflect on and synthesize their learning experiences. If students are rushed, they may not connect new ideas to existing ones.

As an example, rather than introducing a Biosphere or, more specifically, a land cover unit at the beginning of a class period, a teacher could provide a homework activity to introduce the unit. Students could be asked to describe the land cover of their backyards, a nearby park, or other areas close to home. Students would then record their observations in their journals, paying close attention to things that might cause differences in the land cover of their study area. Another example is providing students with reading materials on taxonomy/classification. A teacher would ask students to collect 6-12 different leaf types and sort them into several piles based on similar characteristics. They would record their classification schemes in their journals, and bring their leaves to school the next day for class discussion purposes.

Strategy 6

Accommodate individual learning styles and means of cognitive processing (global or big picture thinking vs. analytical or details-oriented, as examples).

GLOBE *Learning Activities* and *Protocols* allow teachers to create learning experiences that have obvious relevance to students' lives because they provide opportunity to teach and reinforce science, math, and other concepts and principles within the context of the local environment.

Concepts, notions, and ideas are more meaningful to students when they are presented in the context of their everyday lives. Students will increase their understanding of a subject if it has a direct consequence to their own behaviors.

GLOBE *Learning Activities* and *Protocols* are interdisciplinary, providing a vehicle to integrate disciplines on a global scale. Using GLOBE *Learning Activities*, *Protocols*, and Visualizations helps students to analyze materials from both the "big picture" perspective—thinking about implications, patterns, and trends—and analytically by examining and interpreting data or thinking about details of a specific event or phenomenon.

GLOBE *Learning Activities* and *Protocols* foster higher-order thinking through opportunities that consider the how and why of environmental phenomena.

Strategy 7

Use peer and non-peer tutors.

GLOBE projects that use the *Learning Activities* and *Protocols* can be done in a less-structured or student self-paced manner, as well as one in which the teacher provides more structure by pairing students with varying strengths and permitting them to coach and instruct one another. Older GLOBE students in a school or district can also assist and mentor younger GLOBE students with *Protocols*, *Learning Activities*, and research projects.

Strategy 8

Use direct instruction and direct protocol instruction properly.

GLOBE fits well with cooperative learning and other alternate forms of instruction. However, there may be times when a more teacher-centered, direct instructional mode is warranted such as when demonstrating—or teaching how to conduct specific *Protocols* or data entry. Use the following tips to maximize the effectiveness of direct instruction:

- Plan GLOBE activities well ahead of time to ensure there is enough time, materials, etc. to conduct them. Plan an alternate activity in case the weather is not cooperating.
- Know the science and mathematics content related to the investigation to be covered. This helps avoid misconceptions and permits discussion of more complex and abstract issues or items.
- Do not rely on verbal (spoken) and detail oriented introductions all the time.
- Use GLOBE *Learning Activities* and *Protocols* to keep content relevant to students
- Vary the pace of any direct instruction. Some GLOBE activities will require more time and explanation depending on students' grade level. Other activities may have more local relevance and, therefore, warrant more coverage.
- Provide structure AND choices to your students. Permit them to study water quality, for example, in several locations of choice. Or, allow each group of 3-5 students to select which soil type its members wish to study for a class presentation.
- Use homework effectively. Use homework to introduce new materials and reinforce what was done during the day and for student reflection. Asking students to answer "why" questions related to daily GLOBE activities, or to hypothesize where investigation may lead are both effective ways to use homework. Do not turn this time into busy work. For example, have students design a project to investigate what happens to water percolation rates with various types of soil.

Strategy 9

Use computer instruction and other technology wisely.

GLOBE provides many opportunities for students to learn and hone their technical skills through the use of a computer and many other measurement instruments.

- Computer software tends to favor detail oriented students. GLOBE visualizations provide experiential, hands-on opportunities for students to look more globally at patterns and trends, make predictions, and draw conclusions, giving all students the opportunity to learn.
- GLOBE Web-based activities and measuring devices can introduce a topic—serving as the primary lesson components—or reinforce content already introduced. For example, GLOBE graphs of dissolved oxygen and surface water temperature clearly illustrate the inversely proportional relationship of these two variables. Teachers should show students the graphs without prior instruction to develop an explanation or definition of "inversely proportional," or show them the graph to illustrate a concept you have introduced.
- You may have to plan for those times when the Internet is not available, due to intermittent outages, etc. Students can manually graph data, develop picture boards, and use other ways to continue their work. The important part is to not let the technology dictate or rule access to positive learning experiences for students.

Strategy 10

Integrate disciplines in order to help students see connections and real world applications, help place content into a context, and promote deeper understandings.

GLOBE is a means of bringing virtually every classroom in the school together to work on the same mission with other students and scientists worldwide. Students concentrate on *Protocols* in their *science* classrooms and *math* when learning scientific research methodologies and manipulating datasets. *Technology* classrooms utilize GLOBE datasets to create elaborate charts, graphs and maps, comparing their findings with other areas around the world to examine data critically.

GLOBE is the perfect *standards-based* venue to conducting projects involving comparative studies between the over 100 different countries involved in the Program. GLOBE supports the multicultural study of *social studies and geography* by providing students with hands-on experience with basic geographic skills such as understanding latitude, longitude, scale, map elements and spatial analysis.

Additionally, *foreign language classrooms* are provided with authentic opportunities for communication in many languages through GLOBE teacher-to-teacher communication on the GLOBE website, which provide interactive ways for students to work on projects with other schools across town or around the world. Because GLOBE is a worldwide program, many materials are available, as resources allow, in all six United Nations' languages (Arabic, Chinese, English, French, Russian, Spanish). Additionally, GLOBE countries have translated their own materials, such as cloud charts. GLOBE students are introduced to other languages and cultures as they engage in authentic projects and meaningful discussions with one another, students in other countries, and world experts in the disciplines they are studying.

Virtually all classrooms in the school can participate in GLOBE activities. Students build weather stations in their *industrial technology* classrooms while students in *agricultural education* classrooms can actively assist scientists and farmers in the field to better track environmental events effecting crop production. It is also possible to incorporate traditional subjects in the *arts* and *humanities* (art, drama, drawing, music, photography), and *language arts* (descriptive and technical writing, as examples).

GLOBE provides authentic, life-centered curricula and opportunities for meeting the *special needs* found in inclusive classrooms of students with a broad range of abilities and learning styles. Furthermore, opportunities for *cross-age tutoring* encourage school-wide collaboration, respect for the background and perspectives of all students, and enhanced content learning and cooperation. GLOBE activities are also ideal for *after school clubs* and community *service-learning* projects.

GLOBE allows teachers to collaborate between disciplines, provides students with a more integrated view of their own learning, and enables all students to see the interconnection between the various subjects they study. GLOBE encourages all students to behave as scientists and mathematicians while promoting collaboration among all content disciplines in the school.

[i] *National Standards in Foreign Language Education Project.* (1996). Standards for Foreign Language Learning: Preparing for the 21st Century. Yonkers, NY: Author. ERIC Document Reproduction Services No. ED 394 279.

[ii] *Program Standards for the Initial Preparation of Social Studies Teachers.* (2000) National Council for Social Studies, NCSS, 2000.

[iii] *ESL Standards for Pre-K-12 Students.* (1996). TESOL Publications.

Inquiry

Inquiry is demonstrated by:

- Learners who are engaged by scientifically oriented questions.
- Learners who develop their own research questions.
- Learners who give priority to evidence, allowing them to develop and evaluate explanations that address scientifically oriented questions.
- Learners who formulate explanations from evidence to address scientifically oriented questions.
- Learners who evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- Learners who communicate and justify their proposed explanations.[1]

Questions are the key component to inquiry. For a question to be meaningful and relevant for a learner he/she must really care about the answer to it. Both learners and instructors can pose meaningful questions. However, for a question not generated by the learner to motivate genuine inquiry, it (the question) must be taken over and "owned" by the learner.

Inquiry does not have to start with a clearly formulated question—a premise that deviates from the standard "steps of the scientific method" view of student inquiry. Instructors and students have found that some of their most engaging inquiry activities arise only after some preliminary work (observations, collecting data, etc.) on a topic has been carried out, or as a by-product of trying to answer some other question. Questions may also occur quite spontaneously and unexpectedly in the course of reviewing work carried out to date.

The more general point, then, is that inquiry is not a "method" of doing science or any other subject in which the obligatory first stage in a fixed, linear sequence is that of students each formulating questions to investigate. Rather, it is an approach to the chosen themes and topics in which the posing of real questions is positively encouraged, whenever they occur and by whoever they are asked. Equally important as the hallmark of an inquiry approach is that all tentative answers are taken seriously and are investigated as rigorously as the circumstances permit. [2]

GLOBE and Inquiry

The GLOBE Program offers a myriad of opportunities for students to engage in scientific sense-making while they conduct their own inquiry-based research using the data they collect and interaction with their peers and scientists who are applying their data to important research. This collaborative environment promotes a deeper understanding of scientific concepts and allows students to begin grappling with scientific ideas found in the world around them through manipulation of GLOBE data sets,[3] and creation of maps, graphs and visualizations of their data using Multispec and other tools available from the interactive GLOBE website.[4, 5]

[1] National Academy of Science (2000). *Inquiry and the National Science Education Standards,* Washington, DC: National Academy Press, p. 25.

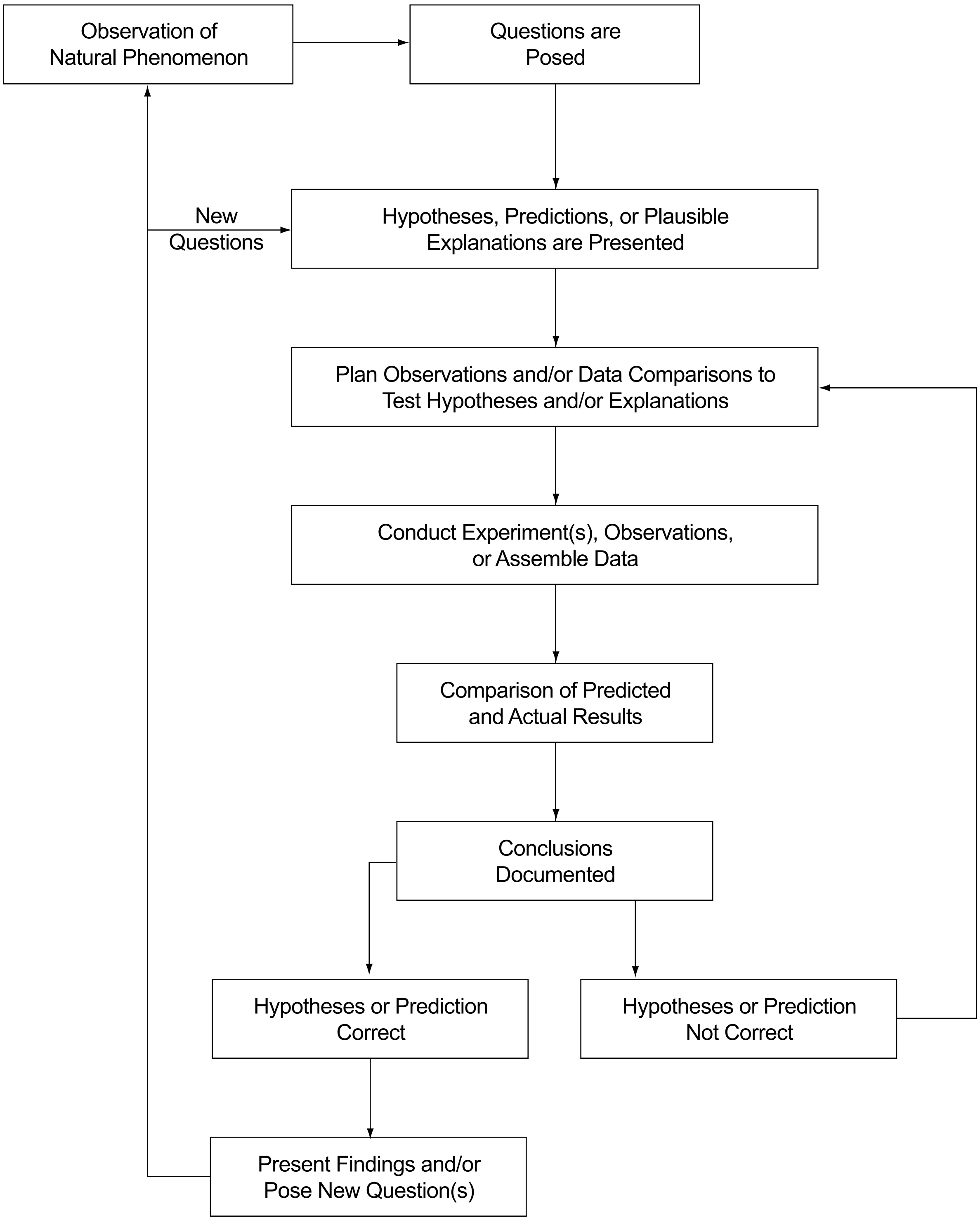
[2] Adapted from: Wells, G. *Dialogic Inquiry in Education: Building on the Legacy of Vygotsky.* Toronto, CA: Ontario Institute for Studies in Education.

[3] NCTM Standards.National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics.* Reston, VA: Author. http://www.nctm.org/standards/

[4] ISTE (International Society for Technology and Education) Standards International Society for Technology in Education (2000). *National Educational Technology Standards (NETS and Performance Indicators for Teachers)* Eugene, Oregon, USA.http://www.iste.org/standards/

[5] ITEA (International Technology Education Association) Standards International Society for Technology in Education. (2000). *National Educational Technology Standards for Students: Connecting Curriculum and Technology.* Eugene, Oregon, USA. http://www.iteawww.org/TAA/Publications/AETL/AETLListingPage.htm

The Process of Scientific Inquiry in Earth Science



Cooperative Learning

GLOBE provides students with hands-on, relevant instructional opportunities to maximize positive learning experiences for all students.

Size and composition: The recommended group size for carrying out a GLOBE investigation is between three and five students. This allows each group member to benefit from the exchange of ideas. It also allows group members to actively observe and monitor each other to ensure the proper procedure is followed for the *Protocol* being investigated. The hands-on nature of the investigations allows students with a range of ability levels to help and support one another.

Assigning roles to students: Groups carrying out GLOBE investigations function effectively when specific responsibilities are placed on individual students. Each student is given a role that plays a part in the whole investigation. The investigation is successful and the data reported are reliable and accurate only if individuals carry their share of the group effort. The following roles are common to all the *Protocol* investigations:

Observers – Each GLOBE investigation requires individuals to make observations about specific scientific phenomenon. As a check for reliability and accuracy, three different individuals should make at least three observations.

Recorder – The recorder documents the observations of the observers. This person writes the observers annotations on corresponding *Protocol Data Work Sheets*.

Data Reporter – The Data Reporter is responsible for inputting data collected by the observers and documented by the recorder into the GLOBE database via the Internet.

Group behaviors: Students working cooperatively together on GLOBE activities will be interacting with each other to perform the investigative tasks at hand. Conversations will be generated as group members share their ideas and contribute their best thoughts to the task. Students will be busy moving around from the outdoor site, to the classroom for laboratory analysis, and then to a computer for data entry.

Five Common Formats for Cooperative Learning

1. Student Teams-Achievement Divisions

Require students to complete a common Work Sheet in groups of four or five, but to take individual tests. The team's score is the result of the individual student's improvement over past performance.

2. Think-Pair-Share

Involves three steps: Students first attempt to answer a question for themselves, then discuss their thoughts with partners, and finally share the combined effort with a small group or class.

3. Jigsaw

Uses teams of three to six. Each group member is given a piece of information and asked to teach it to the others. Students can also obtain their own information to share. Students are then tested individually.

4. Team Accelerated Instruction

Combines individualized instruction and cooperative learning. Students are assigned materials at their level and assisted by peers. Group points are obtained through high achievement or improvement on individual tests.

5. Group Investigation

Is a higher-level process in which students accept greater responsibility for their own learning. Small groups decide what to investigate, what contributions each member will make, and how to communicate what they have learned.

Student Roles

The following is a sample of 10 team roles arranged from least to most challenging:

1. Initiators

Get the group started by stating the task and reminding the team to stay on task if attention wanders.

2. Quiet Captains

Remind group when voices are getting too loud.

3. Timekeepers

Inform the group of how much time is left and whether the group seems to be on schedule.

4. Cheerleaders

Encourage the group to give positive feedback to group members.

5. Equalizers

Attempt to equalize participation by encouraging less involved students to contribute.

6. Recorders

Write down each significant step, decision, question, or statement to be shared with the class.

7. Presenters

Read the group decision or describe the group project to the class.

8. Coaches

Help peers to master materials but do not do the work for them.

9. Reflectors

Summarize each person's contributions or comments to the group on how well they have worked together to complete their task(s).

10. Question Commanders

Attempt to answer teammates' questions or redirect questions to team members before appealing to the teacher for help.[1]

Other roles include: facilitators, quality controllers, and technicians.

For more information on cooperative learning, see the following web sites:

http://www.jigsaw.org/steps.htm

http://www.utc.edu/Teaching-Resource-Center/CoopLear.html

http://www.ed.gov/pubs/OR/ConsumerGuides/cooplear.html

http://www.atozteacherstuff.com/articles/cooperative.shtml

Student Assessment

1. GLOBE Portfolios

Students create a portfolio of measurements, reports and analysis of various Protocols within investigation areas.

Student portfolios should provide evidence of skills and concepts that have been learned over a period of time—they are much more than a "folder of student work!" Items to go into a portfolio should be carefully selected by students and teachers, and should represent a cross-section of the student's individual creative efforts. Over the course of the year these efforts will involve discussions of ideas among students and the portfolio contents should show how they understand those ideas. Students will gain experience looking at problems in new ways and will learn how to evaluate their own work.

Example:

Portfolios can be designed around themes—such as the GLOBE project—or around something such as Basic Science Process Skills, which also fits in nicely with GLOBE Protocols and *Learning Activities*. The basic science process skills are observation, classification, communication, measurement, estimation, prediction, and inference. Teachers may wish to develop skills such as constructing operational definitions and controlling variables.

Students should select examples of their project work that reflect their growth and understanding of each of the process skills as they work through their GLOBE projects from start to finish. Some examples of categories for selection of portfolio items are,

- sample of work that illustrates a problem that was difficult;
- work that shows how student started to figure out the problem and solve it;
- sample that shows a solution was reached;
- sample that shows that something new was learned;
- sample of work in which the student needs to keep searching for ideas because the solution is incomplete;

- item of which the student is particularly proud; and
- example of a mistake that turned into a positive learning situation

To further define what a portfolio might contain, the following are specific examples of items that might be selected to fit into the above categories:

- Group assignments and team ideas.
- Any comments and assessments of work – self or from someone else.
- Things written by student.
- Reflections of student about a task, journal entries, reactions and feelings to a particular task or activity, collected data entries, logs, and research.
- Problems and investigations.
- Individual and group projects.
- Creative expressions such as art, audio- and videotapes, and photographs.
- Rough drafts with completed products.

Items selected should be dated and accompanied by a caption and description. Teachers may also consider giving students the freedom to delete, improve, or change the contents of their portfolios prior to evaluation.

How will I evaluate a portfolio?

Portfolios are usually evaluated in several ways. For our example, an evaluation might consider:

- **Evidence of Critical and Creative Thinking** – Examining portfolio for evidence that the student's work shows that he/she
  - Organized and displayed data
  - Could see and analyze patterns
  - Understands the scientific process
  - Used concrete materials such as drawings or sketches to help interpret and analyze problems
  - Used technology (computers, graphics, calculators) to solve problems
  - Searched for information and critically examined data
- **Quality of Activities and Investigation** – Examine portfolio for examples of how student work helped him/her develop an understanding of the basic science process skills
- **Variety of Approaches and Investigations** – Does the student portfolio show that he/she has used a variety of ways to solve problems?
- **Demonstration of Understanding and Skill of Prior Learning** – The portfolio should provide evidence that the student understands the reason for using certain procedures and methods, what is being looked for with each investigation or activity, and what the data mean.

  Note: Students should also be provided with an opportunity for self-evaluation of their portfolios at the end of the grading period, semester, or year.

2. Performance Tasks

Students take measurements and input them into the database. You can evaluate students' ability to independently carry out the *Protocols* and record data.

3. Rubrics

Rubrics are printed sets of scoring guidelines or criteria that teachers use to evaluate work and to give feedback.

Rubrics can be designed that measure students' ability to carry out *Protocol* investigations. A rubric can be developed for one specific activity, or can be more generic to cover each group presentation that will be made.

Students should be provided with a rubric for assignments at some point prior to the evaluation. This enables them to have some important information about the work they are about to do

- By what criteria will you judge their work?
- What are the differences between work you view as "good" and work you think is "not so good?"
- How can they focus their preparation and tasks on achieving good results?

A good rubric should contain the following components:

1. **The Performance Element** to focus best practice, such as “Creativity,” Quality of Writing,” or “Use of GLOBE Data in Analysis.”

2. **Scale.** The possible points to be assigned (from high to low).

3. **Criteria.** What are the conditions of performance that must be met in order for the work to be considered as successful?

4. **Standard.** How well must the criteria be met in order for the work to be considered as “good?”

5. **Descriptors.** Describe each level of performance.

6. **Indicators.** “Real” examples of what to look for at each level of the performance in order to measure learning.

The following web sites provide useful background information and many sample rubrics, as well as free tools to help you design your own rubrics.

http://school.discovery.com/schrockguide/assess.html#web

http://rubistar.4teachers.org/

http://www.teach-nology.com/web_tools/rubrics/

http://landmark-project.com/classweb/tools/rubric_builder.php3

[1] Adapted from Leaver, B. (1997). *Teaching the Whole Class, 4th Ed.* Corwin Press.

Sample Generic Rubric - For Science Project				
Category Idea	Indepenently identified question that was interesting and that could be investigated.	Identified, with adult assistance, question that was interesting and that could be investigated.	Identified, with adult assistance, a question that could be investigated.	Identified a question that could not be investigated or that did not merit investigation.
Hypothesis Development	Idependently developed hypothesis well-substantiated by literature review and observation of similar phenomena.	Independently developed hypothesis somewhat substantiated by literature review and observation of similar phenomena.	Independently developed hypothesis somewhat substantiated by literature review or observation of similar phenomena.	Needed adult assistance to develop a hypothesis or to do a basic literature review.
Description of Procedure	Procedures outlined in step-by-step fashion that could be followed by anyone without additional explanation. No adult assistance needed.	Procedures outlined in a step-by-step fashion that could be followed by anyone without additional explanation. Some adult assistance needed.	Procedures outlined in a step-by-step fashion, but had 1 or 2 gaps that required explanation even after adult feedback had been given.	Procedures that were outlined were seriously incomplete or not sequential, even after adult feedback had been given.
Variables	Independently identified and clearly defined which variables were going to be changed and which were going to be measured.	Independently identified which variables were going to be changed and which were going to be measured. Some feedback was needed to clearly define variables.	With adult assistance, identified and clearly defined which variables were going to be changed and which were going to be measured.	Adult assistance needed to identify and define almost all the variables.
Data Collection	Data collected several times, summarized independently, in a way that clearly describes what was discovered.	Data collected more than one time. It was summarized independently, in a way that clearly describes what was discovered.	Data collected more than one time. Adult assistance needed to clearly summarize what was discovered.	Data collected only once and adult assistance needed to clearly summarize what was discovered.
Conclusion and Summary	Provided a detailed conclusion clearly based on the data and related to previous research findings and the hypothesis statements.	Provided a somewhat detailed conclusion clearly based on the data and related to the hypothesis statements.	Provided a conclusion with some reference to the data and the hypothesis statements.	No conclusion was apparent OR important details were overlooked.

Created using http://rubistar.4teachers.org/

GLOBE Student Journal Grading Criteria

Four Requirements Must Be Met For Entry To Be Considered:

1. A research question must be asked.
2. GLOBE data and/or protocols must be used to help answer the research question.
3. Data used must be presented in the report.
4. A conclusion to the research question must be presented in the report.

Standard Grading Items (max 100 points total):

(See following pages for descriptive criteria.)

Points	Strength of research question	Extent and effective use of GLOBE data and/or protocols	Demonstrated understanding of research question and its relation to observations	Depth/Quality of data analysis and use of tables and graphs to illustrate this	Discussion of measurement procedures and limitations	Strength of Conclusion	Logical and clear flow from question to conclusion
0							
3							
6							
9							
12							
Total							
					Subtotal (max 84)		

Points	Abstract	Citations	Report Format	Neatness and Presentation	
0					
2					
4					
Total					
				Subtotal (max 16)	
				Standard Total (max 100)	

Extra Credit Items (max 15 points total):

	Points (0-3 each)
Discussion of topic background given	
Use of supplementary (non-GLOBE) relevant data	
Investigation had impacts outside of the classroom	
Illustrations and/or graphics of exceptional quality and creativity that would indicate the possibility of a strong oral/poster presentation	
Research question that indicates student(s) have done considerable background research into topic	
Extra Credit Total (max 15)	
Total Points (standard + extra credit) (max 115)	

Research and Analysis 84 Points Total

Points	Strength of research question	Extent and effective use of GLOBE data and/or Protocols	Demonstrated understanding of research question and its relation to observations	Depth/Quality of data analysis and use of tables and graphs to illustrate this	Discussion of measurement procedures and limitations	Strength of Conclusion	Logical and clear flow from question to conclusion
0	*No research question is asked*	*No GLOBE data or protocols are used or the Protocols are used incorrectly.*	*No indication is given that students have reflected on their research question and its relation to observations.*	*No analysis of data is performed OR no data are presented.*	*No discussion of measurement procedures is present.*	*No conclusion is present or the conclusion is not relevant.*	*There is no logical flow through the paper.*
3	*A research question is asked, but it is not clearly explained, has an obvious answer, does not require scientific research to be answered, or is clearly beyond the scope of such a report.*	*Use of GLOBE data and/or protocols is only a small portion of the investigation, or use is not relevant to answering the research question asked.*	*Minimal indication is given that students have reflected on their research question and its relation to observations.*	*Data analysis is performed but is too simple to address the research question or is illogical, poorly explained, or disorganized. The presentation of data in tables and/or graphs is incomplete or disorganized or fails to convey relevant information.*	*The discussion of procedures is vague or contains significant errors. There is no discussion of the limitations of the procedures used. No analysis of errors is attempted.*	*A conclusion is present and relevant to the report but is not supported by the data. No explanation is given for how the conclusion was reached.*	*Some sections of the paper are clearly and logically related to one another.*
6	*A research question is asked and explained. It is answerable through scientific research appropriate to the scope of this report, but the question is not particularly insightful or interesting.*	*GLOBE data and/or protocols are used, but not enough data are presented to answer the question, or a considerable amount of data included is not relevant to the question OR a protocol or procedure was omitted that is needed to address the research question.*	*Students have reflected on the research question and its relation to the observations. Insights into the meaning or importance of the question or its relation to observations are not given, are erroneous, or are trivial.*	*An analysis of the data is performed that is appropriate to the research topic but the analysis is incomplete, or is not clearly explained and presented. The presentation of data is incomplete or unclear.*	*A clear but incomplete discussion of the procedures is given. The limitations of the methods used are not discussed. The analysis of errors is attempted but is incorrect.*	*A conclusion is present and supported by the data, but no explanation is given as to how the conclusion was reached.*	*The paper flows clearly and logically from beginning to end with at most two exceptions.*
9	*A clear research question is asked and explained. Answering the question requires a thoughtful research plan, and the question is of scientific interest.*	*GLOBE data and/ or protocols are used, and the data presented are sufficient to answer the research question.*	*Students have reflected on the research question and its relation to the observations. Good insights into the meaning or mportance of the question or its relation to observations are given.*	*A solid analysis of the data is performed. It is clearly explained and addresses the research question. The use of tables and graphs is appropriate and illustrates the analysis.*	*A clear and complete discussion of the procedures is present and some discussion of limitations of the methods used is included. Analysis of errors has been attempted.*	*A conclusion is present and supported by the data. An explanation is given as to how the conclusion was reached.*	*The paper flows clearly and logically from beginning to end.*
12	*A challenging and creative research question is asked that will provide significant insight into both the topic of investigation and the research process. Answering the question requires a clear understanding of the subject matter.*	*Full advantage is taken of GLOBE data and protocols. There is little more that could be done with additional GLOBE protocols or types of GLOBE data to answer the research question.*	*Students show that they have reflected on the research question - its importance and meaning. Students clearly understand the relation of the question to observations. At least one deep insight is provided or one clear connection of the question to a larger topic is explained.*	*An insightful and careful analysis ofthe data is presented. It is scientifically valid, well explained, and fully addresses the question posed. Any mathematics and equations are presented clearly defining the analysis. Tables and graphs provide clear, easily understood illustration of the analysis.*	*A clear, complete and insightful discussion of the procedures and their limitations is present. Error analyses are included and are performed correctly.*	*A thoughtful conclusion is present and supported by the data. A thorough and insightful explanation is given as to how the conclusion was reached and how it is supported bythe data analysis.*	*There are clear complete ties among all elements of the paper. The paper flows ina logical and coherent manner without any unneeded elements.*

Communication 16 Points Total

Points	Abstract	Citations	Report Format	Neatness and Presentation
0	No Abstract is present.	Citations are not present.	Report is disorganized or does not contain most of the required elements.	Report is poorly presented, and/or sloppy, or contains numerous spelling and grammatical errors.
2	An abstract is present but is incomplete, does not summarize the report, or exceeds the designated word limit.	Materials used are cited but citations are incorrect or incomplete.	Report is organized and contains most of the required elements	Report is neat and well presented but contains greater than five spelling andgrammatical errors.
4	An abstract is present that is complete, summarizes the report, and does not exceed the designated word limit.	Materials used are cited completely and correctly.	Report is well organized and contains all of the required elements.	Report is neat and well presented and contains no more than five spelling or grammatical errors.

4. Science Journals

Students keep a regular journal of their GLOBE experiences, with opportunities to respond to specific teacher questions about the activities or other opportunities to free-write. Teachers are encouraged to submit student research reports involving GLOBE protocols and data to the GLOBE website.

Writing through journals or other assignments is a tool for connecting thought, feeling and action by combining reflective practice, critical thinking, and self-awareness—an essential for this connection is the own experience of the learner. In the mid 1930's, John Dewey helped shape the relationship between school and society with the publication of his book, *Experience and Education*. His ideas of how school should be were based on individuals learning through a complex intellectual operation entailing observation of surrounding conditions, and knowledge of similar experiences from the past. Dewey, in conjunction with present day researchers, proposed students learn best when interest is cultivated with topics applicable and pertinent to their own lives. In essence, students learn best when they are able to tailor topics to fit their individual meaning, while contributing their own culture and perspective to the learning process. Hence, the connection linking prior learning to new learning includes reflection to establish a meaningful link to learners' own lives.

Experience + Reflection = Growth. As this equation suggests (and as John Dewey has argued), we do not actually learn from experience as much as we learn from reflecting on experience. Experiential reflection is best used through journal and writing practice in the classroom setting. Journals/writing help students and instructors connect material to applicable situations and personal experiences. The purposes for journals/writing include: creating personal connections to the content, providing a place to ponder the content, collecting observations and data, and providing for the practice of writing. Journals/writing also help students and instructors synthesize experience, content, and theory.

Many GLOBE *Learning Activities* and *Protocols* provide opportunities for reflection because of the opportunities they present for students to explore their own environment, identify their own questions, and test predictions that are based on prior knowledge. Asking students to reflect on the "how" and "why" of a particular observation is an important activity that can lead to curiosity, more depth of understanding of content, and integration of facts from several disciplines. Peer review of student journals or other reflective writing assignments provide an additional opportunity for students to think critically and relate prior knowledge and experience to new information.

5. Open-Ended Questions

Open-ended questions allow students to answer in a variety of ways. They allow teachers to draw out information from students to gauge understanding of a particular subject matter and the connections students are able to make. Open-ended questions allow for discussion. Open-ended questions focus on students' understanding, their ability to reason, and their ability to apply knowledge in a variety of contexts and across subject areas. The nature of open-ended questions allows students to approach problem solving from many different angles.

Teachers can also use a technique known as *question-level sequencing* in which they start with a closed-end, knowledge-based question and build to more complex open-ended questions.

Move from

- Easy to difficult
- Singular to complex
- Experience to abstraction

More specifically, teachers would move through a series of questions using the following model:

Opening Questions

- General questions that direct students into a text or their notebooks for an answer
- Introduce and explore ideas, topics, and themes

Core Questions (2-5 questions)

- Content specific
- Examine central points

- Interpret a passage, explore a quotation

Closing Questions

- Establish relevance
- Connect with real world
- Apply to self

Some examples from the GLOBE soils investigation area are the following (in the context of Bloom's taxonomy):

- What are the three main components of soil? (air/water, minerals, organic matter).
  - Which of these will decrease with rainfall?
  - Why do you think that will happen?
  - We learned about the relative proportions of each of these materials in a soil that is good for plant growth. What is it about each of these components that makes it important for the soil, and why is the proportion important for plant growth?
- Write a definition of bedrock.
- Is parent material different from bedrock?
  - If yes, how?
  - Do you think it is possible to have a soil located on a bedrock composed of different materials (minerals, etc.)?
- Why or why not?

6. Performance-based Assessments

These are questions, tasks, or activities that require students to perform an action. Although performances can involve demonstrations or presentations, they usually involve students explaining how they would answer a question or solve a problem by writing a few sentences or paragraphs, drawing and explaining a diagram, or performing an experiment. Such tasks may take from 15 minutes to an hour or more and may involve some work with a group of students who think through the answers and later provide their own individually written answers.

Traditional paper and pencil tests help answer the question, "Do you know it?" and performance assessment helps answer the question, "How well can you use what you know?" or "How well have you learned to perform the skills you have been taught and practiced?" The challenge is to find the right balance between performance-based and other means of effective assessment.

Performance assessments provide students with the opportunity to use knowledge, skills, and decision-making as well as their capabilities to integrate across disciplines and tasks. Performance tasks:

- Require students to use knowledge and skills in the context of real-life situations or issues.
- Demonstrate the extent to which individual students deal with a particular situation, not just the end result.
- Integrate multiple learning outcomes that are content- and skills-based.
- Require the use of complex reasoning.
- Focus on multiple dimensions of students' learning, demonstrating whether something is understood for application or just memorized.[1]

GLOBE and Learning

What science process (thinking) skills do students use to carry out GLOBE activities?

GLOBE students learn science concepts by investigating and experiencing the world around them through hands-on activities. The hands-on approach of the GLOBE Program allows students to actively experience science by doing real experiments and critically analyzing data. GLOBE investigations and learning activities require students to gather information through the senses (observing), exchange and discuss ideas (communicating), look at similarities and differences (comparing), sequence events (ordering), group objects or events by like characteristics (categorizing), recognize interactions, dependencies, and cause-and-effect relationships (relating), reason logically using observed evidence (inferring), and put knowledge to work to understand phenomenon and problems (applying).

To what extent are math, reading, writing, social studies, the humanities, and technology integrated into GLOBE activities?

Each GLOBE *Learning Activity* and *Protocol* has a "Gray Box" at the beginning that provides teachers with relevant educational and planning information about the activity/protocol. Science, geography, mathematics, and scientific inquiry concepts and skills are provided which align with the National Science Education Standards. In addition, most activities and protocols include a section outlining enrichment activities. The worldwide contribution to the GLOBE database makes incorporation of social studies activities into any learning activity and protocol investigation an easy task. Any student data from one local area can be compared to data from another state, region, or country in the world.

Students' motivation to learn is peaked when they are given a sense of meaningfulness in regard to their studies. Because GLOBE links teachers and students around the world, it fosters alliances among students and increases not only their environmental awareness but also their understanding of other cultures and their sense of a global community. GLOBE allows teachers to put the concepts of authentic learning, student-scientist partnership, scientific inquiry and standards-based pedagogy into practice on an unprecedented scale.

Scaffolding

The GLOBE *Teacher's Guide* and its contents allow teachers to scaffold their lessons:

Teachers are challenged to deliver standards-based learning in an efficient and effective way. One method teachers can use to meet this challenge is to design unit and lesson plans that are **scaffolded** to allow students to connect new ideas to existing ideas at their own levels of understanding. Teachers scaffold by reducing complex tasks to manageable steps and helping students concentrate on one task at a time. This permits students to become independent thinkers. Teachers must assess students' current levels of competence and ensure that classroom experiences and assignments assist them in achieving the desired level of competence.

GLOBE enables scaffolding by,

- providing opportunities for varied approaches to presenting content;
- providing age-appropriate, adaptable content through printed material and the Web;
- maintaining a Web site as a resource and infrastructure for publishing student reports, sending email across the world, and for Web chats with scientists. GLOBE activities also lend themselves well to cooperative learning and other discussion-oriented activities;
- providing activities that enable student reflection, revision, practice, and extension;
- encouraging students to apply what they know to new situations; and
- promoting independence of students by providing multiple opportunities to participate and contribute to a class project, or by conducting independent projects.[2]

Example (Using extrapolation):

Have students analyze data for their school, county, state, region, country, and continent. Let them first see how measurements vary for an area they are familiar with and for which they have taken the measurements themselves. Then extrapolate to a larger area. Relate to them how scientists are using the data on a larger scale and the students' data collection is contributing to this effort.

Scaffolding through GLOBE involves,

1. teaching GLOBE activities in a problem-solving environment;
2. using scientific evidence from GLOBE activities for verification;
3. applying critical thinking skills through GLOBE activities; and
4. connecting GLOBE activities into a larger picture.

[1] *Improving America's Schools: A Newsletter On Issues in School Reform*, funded and distributed by the U. S. Department of Education

[2] Source: Adapted From Gay, G. Ontario Institute for Studies in Education, Toronto, Ontario, Canada.

Science Materials and Information

Selecting Your GLOBE Study Sites

Initial Considerations

The selection of the local study and sample sites can be an opportunity to begin an inventory of the area around the school, and to discuss criteria for measurement sites. What is a good place to measure water temperature, and why? What do you have to consider when planning where to dig a soil profile? Where can you get representative samples of soil moisture, and what might influence the choice of sampling strategy? How can Landsat imagery help with these decisions? These are only a few of the multiple questions that can serve as catalysts for learning.

For each measurement site within your GLOBE Study Site there will be hard choices to make because no one will have a perfect set of locations. This is an opportunity to work on solving problems with your students in order to come up with the best arrangement for your class, your school, and your schedule. We suggest you try to come up with several candidates for site selection and have your students be active participants in the selection process.

GLOBE Study Site

Your GLOBE Study Site, the area where most of your scientific protocols will be conducted, is approximately a 15 km by 15 km area with your school near the center. All of the individual study sites are located within this larger GLOBE Study Site. Landsat images are available at several sites on the Internet. From an instructional standpoint, the goal of these sites is to give your students a feel for the physical resolution of satellite images as well as providing a suitable and convenient area upon which to focus student measurement activities.

Within your 15 km x 15 km GLOBE Study Site, you will select several specific study sites, corresponding to the individual protocols: Atmosphere, Biosphere, Hydrosphere, and Soil Moisture as detailed below. Once established, these study sites are locations to which students will return again and again to take measurements. The *Land Cover* and Soil Characterization Protocols involve measurements which are done only once at specific locations which are referred to as sample sites.

Study Site for Atmosphere

Study sites are defined generally and have various protocols associated with them. Typically, you and your students will conduct most of the atmosphere protocols at a site in close proximity to your school, so that students will have easy daily access to the instruments. These protocols may include temperature, precipitation, cloud type and cloud cover, aerosols, or surface ozone. Several siting considerations for these protocols are detailed below.

1. Measurements of cloud cover and cloud type require an unobstructed view of the sky. The middle of a sports field or parking lot is an excellent location.
2. For measurements of precipitation, the rain gauge (and snowboard) must be in an open area with a natural (e.g. grassy) surface. Do not place the rain gauge close to buildings, trees or high bushes, which can affect the amount of rain that collects in the rain gauge. An open field, a playground, or the side of a sports field are excellent locations for the rain gauge. The snowboard should also be placed in an open area, away from buildings, with special care to select a place where snow shoveling will not pile snow onto or clear snow from the board.
3. For measurements of air temperature, you need to put the thermometer in a small standardized, protective shelter. This shelter, painted white, with slats on the sides to let air circulate, is mounted on a post. The shelter has a door, enabling students to look in to

read the temperatures. As with the rain gauge, the instrument shelter should be in an open area with a natural (e.g. grassy) surface, away from buildings, trees or high bushes.

If possible, include soil moisture measurements at or near the site where you collect precipitation data, as the rain data will help students and scientists better understand the soil moisture data.

Some schools do not have large open areas for mounting their instrument shelter and ran guage. GLOBE encourages such schools to describe carefully all the ways in which their site differs from the criteria given in this guide and to report this information on the *Site Definition Sheet*. For more details, refer to the *Atmosphere Investigation*.

Hydrosphere Study Site

Water characteristics will be measured in your GLOBE Study Site, at a body of water, such as a lake, river or stream. There are two steps to selecting your Hydrosphere Study Site. First, you need to determine which bodies of water (streams, rivers, lakes, bays, the ocean, ponds, and reservoirs) are in your GLOBE Study Site. You can determine this from local maps or from the Landsat image of your GLOBE Study Site. Second, you need to select one that is most appropriate for the *Hydrosphere Investigation*.

Ideally, the Hydrosphere Study Site should be within the major watershed of the 15 km by 15 km GLOBE Study Site, and connected to water systems that flow into larger river or estuary systems. This means that if your site includes more than one watershed, you have to figure out which one is most important. Within this watershed, select a specific site where the hydrosphere measurements (water temperature, dissolved oxygen, nitrate, pH, alkalinity, turbidity, and either conductivity or salinity) will be taken.

If the selected study site is a moving body of water (i.e. stream or river), locate your sampling site at a riffle area as opposed to still water or rapids. This will provide a more representative measurement of the water in the stream or river.

If the selected study site is a still body of water (i.e. a lake or reservoir), find a sampling site near the outlet area or along the middle of the water body. Avoid inlet areas. A bridge or a pier are good choices. If your water body is brackish or salty, you will need to know the times of high and low tide at a location as close as possible to your study site.

Hydrosphere measurements should be taken weekly, and therefore it is important that your study site be easily accessible to students on a routine basis. A site which is ideal from a science perspective but where transportation problems prevent students from taking measurements regularly is not as good as an acceptable site whose location is conducive to routine observations.

Soil Study and Sample Sites

For the *Soil (Pedosphere) Investigation*, there are two collections of protocols that can be collected at study sites: soil characterization protocols and soil and temperature protocols.

When collecting soil characterization data, holes will be dug to expose the soil profile and permit the collection of soil samples and the examination of the various soil layers or horizons. These data can be collected in the same general location of biometry (land cover) data in order to link the soil type with land cover characteristics. These data should also be located as close as possible to the site where soil moisture data are collected. In this way, the soil properties needed to interpret soil moisture measurements can be determined.

When collecting soil moisture data, either of two soil moisture measurement techniques may be employed. The first uses a technique called gravimetric and/or volumetric sampling and simply involves collecting soil samples and drying them to determine their moisture content, mass and volume. Samples should be collected at least12 times during a year, and the timing and pattern of collection are chosen by you and your students from a set of options described in the *Soil (Pedosphere) Investigation*. The second, which is optional and only recommended for advanced students in areas where the soil is not acidic, involves burying moisture sensors at four specified depths in the soil and collecting readings from the sensors on a daily basis.

Wires extend from the buried blocks to the surface, and to take a reading, you connect a meter to each pair of wires in turn.

The time it takes water to infiltrate the soil and the near-surface soil temperature are measured at sites where soil moisture data are collected. The timing and sampling pattern for these observations along with the details on all soil measurements are described in the *Soil (Pedosphere) Investigation*.

When collecting soil moisture and temperature data it's recommended that atmosphere data, especially air temperature and precipitation, are also collected. This will enable correlation of the atmospheric data with the soil moisture and temperature data.

Biosphere (Land Cover) Study and Sample Sites

In the *Biosphere Investigation* students monitor the seasonal changes in vegetation (Phenology) and characterize the land cover by making land cover classification observations at a number of sites. The data from these sample sites can be compared with Landsat data and images of your 15 km by 15 km GLOBE Study Site to determine the accuracy of the satellite observations.

Sites where land cover data are collected can be used to document land cover characteristics. One of the requirements for including land cover protocols at a site is that they are 90 m by 90 m in size and contain similar (homogeneous) cover. These characteristics are needed to enable verification of satellite data.

As you have time (perhaps over several years) your students should collect land cover data at one site for each major type of land cover found within your 15 km by 15 km GLOBE Study Site. In GLOBE, land cover is classified using the Modified UNESCO Classification (MUC) found in the *Biosphere Investigation*.

Land cover data are collected at a site which is typically 90 m by 90 m area of natural vegetation. Biometry measurements are made once or twice each year – in the growing season and in the adverse season if there is one, so access to the site is less of an issue than for sites of more frequent measurements. Students can practice biometry observations at a location adjacent to the school.

For further information on setting up these Land Cover Sites, see the *Biosphere Investigation*.

Master List of GLOBE Protocols

This is a comprehensive list of the GLOBE *Protocols* (measurements) your students can take as active participants in the GLOBE program. The *Protocols* are arranged by investigation area.

Investigation Area	Recommended Measurement Frequency Range						
Atmosphere	Daily	Weekly	Monthly	Seasonally	Semi-Annually	Annually	Once per site
GPS Measurement Protocol							X
Instrument Construction, Site Selection and Setup							X
Cloud Protocols	X						
Aerosol Protocol	X						
Water Vapor Protocol	X						
Barometric Pressure Protocol	X						
Relative Humidity Protocol	X						
Precipitation Protocols (based on local precipitation)	X	X	X	X			
Maximum, Minimum, and Current Temperature Protocol	X						
Digital Multi-Day Maximum/Minimum Soil and Air Temperatures Protocol	X	X					
Automated Soil and Air Temperature Monitoring Protocol		X	X				
Surface Temperature Protocol	X						
Surface Ozone Protocol	X						
Earth Networks Protocol			X				X
Automated Weather Station Protocols		X					

Investigation Area	Recommended Measurement Frequency Range						
Hydrosphere	Daily	Weekly	Monthly	Seasonally	Semi-Annually	Annually	Once per site
GPS Measurement Protocol							X
Instrument Construction, Site Selection and Sampling Procedures							X
Water Transparency Protocol		X					
Water Temperature Protocol		X					
Dissolved Oxygen Protocol		X					
Electrical Conductivity Protocol		X					
Salinity Protocols		X					
Water pH Protocol		X					
Alkalinity Protocol		X					
Nitrate Protocol		X					
Freshwater Macroinvertebrates					X		
Optional Salinity Titration		X					

Frequency Key

Daily, Weekly, Seasonally, Annually

Twice Weekly, Monthly, Semi-Annually, Once per site

Investigation Area	Recommended Measurement Frequency Range						
Soil (Pedosphere)	Daily	Weekly	Monthly	Seasonally	Semi-Annually	Annually	Once per site
GPS Measurement Protocol							X
Selecting and Defining a Site for Soil Characterization Protocols; Exposing a Soil Profile							X
Soil Characterization Protocol							
Soil Temperature Protocol	X	X		X			
Automated Soil and Air Temperature Monitoring Protocol		X	X				
Digital Multi-Day Maximum/Minimum Soil and Air Temperature Protocol	X	X					
Digital Multi-Day Soil Temperatures Protocol		X					
Gravimetric and Volumetric Soil Moisture Protocol	X	X	X	X			
Soil Moisture Sensor Protocol	X						
Bulk Density Protocol							X
Soil Particle Density Protocol							X
Particle Size Distribution Protocol							X
Soil pH Protocol							X
Soil Fertility Protocol							X
Water Infiltration Protocol				X			
Davis Soil Moisture and Temperature Station Protocol		X					

Investigation Area	Recommended Measurement Frequency Range						
Biosphere	Daily	Weekly	Monthly	Seasonally	Semi-Annually	Annually	Once per site
GPS Measurement Protocol							X
Site Selection							X
Investigation Instruments							X
Land Cover Sample Site Protocol							X
Biometry Protocol*				X			
Fire Fuel Ecology							X
Green-Up and Green-Down Protocols	X	X		X			
Ruby-Throated Hummingbird Protocol	X	X		X			
Lilac Phenology Protocol	X			X			
Phenological Gardens Protocol		X					
Seaweed Reproduction Phenology Protocol			X	X			
Arctic Bird Migration Monitoring Protocol		X		X			

* Ongoing activities until study site is completely mapped

Frequency Key

- Daily
- Weekly
- Seasonally
- Annually
- Twice Weekly
- Monthly
- Semi-Annually
- Once per site

Additional Science and Inquiry Concepts

These are science and inquiry concepts found in the protocols and learning activities for the GLOBE investigations but which have not already been listed in the National Science Education Standards tables.

Atmosphere

Earth and Space Science Concepts

The atmosphere has different properties at different altitudes.

The diurnal and seasonal motion of the sun across the sky can be observed and described.

Clouds can be described by quantitative measurements.

Clouds change over different temporal and spatial scales.

Clouds are identified by their shape, altitude, composition, and precipitation characteristics.

Clouds help us to understand and predict the weather.

Aerosols decrease the amount of solar energy reaching Earth's surface.

Aerosols in the atmosphere increase haze, decrease visibility, and affect air quality.

Precipitation forms by condensation of water vapor in the atmosphere.

Air pressure is a measure of the weight of the atmosphere per unit area.

Changes in barometric pressure can be used to help predict weather.

Water circulates through the biosphere.

Soil temperature varies with air temperature.

Soil temperature varies less that air temperature.

The path length of incident sunlight through the atmosphere (relative air mass) varies as a function of the solar elevation angle.

Geography Concepts

Human activities can modify the air quality and the composition of the atmosphere.

Biosphere

Earth and Space Science Concepts

The surface of the Earth changes.

Physical Science Concepts

Measuring instruments can be used to gather accurate information.

Objects have observable properties that can be measured using these properties..

Objects have observable properties that can be measured using tools.

People can often learn about things around them just by observing.

Describing things as accurately as possible is important.

Symbols are alternative ways of representing data.

Life Science Concepts

Organisms have basic needs.

Dominant plant species.

Green-up varies among different locations.

Green-up is related to climate.

Green-up marks the start of photosynthesis for the season.

Humans can change ecosystem balance.

Each plant has different structures but some plants are alike in the way they look.

Plants have features that help them live in different environments.

Geography Concepts

The changing physical and human characteristics of places

The characteristics and spatial distribution of ecosystems.

Human activities influence changes in ecosystems.

How to analyze the spatial distributions and patterns of population.

Maps and satellite-produced images.

How to display spatial information on maps and other geographic representations.

Local and global patterns of ecosystems.

The relative advantages and disadvantages of using maps, satellite images, and models to solve geographic problems.

How to use geographic knowledge, skills, and perspectives to analyze problems and make decisions.

How to use technologies to represent and interpret Earth's physical and human systems.

How places change over time.

The distribution of major physical features at different scales.

How to describe the student's own region from different perspectives.

The spatial concepts of location, distance, direction, and scale.

Characteristics, functions, and applications of maps, globes, and satellite images.

Science and Technology

Technology is essential to science.

People have always had questions about the world. Science is one way of answering questions.

Scientists in different disciplines ask different questions, use different methods of investigations.

Scientists rely on technology to enhance the gathering and manipulation of data.

Clear communication is an essential part of doing science.

Land Cover Enrichment

Clustering is a way to separate different land cover classes using spectral patterns.

Assessing

the accuracy of a land cover type map.

A homogeneous 90 m x 90 m Land Cover Sample Site can be considered a system.

Your system includes components such as plants, water, soil, rocks, and animals.

Your system has inputs such as solar energy, water, carbon dioxide, oxygen, and dust.

Your system has outputs such as water, carbon dioxide, oxygen, heat, and waste products.

A map is a symbolic representation of a certain area.

A map of the same area can be represented with different scales.

Field of view is how large an area you can perceive.

The field of view increases as the distance from the ground or object increases.

Remote sensing in collecting data about something from a distance.

Objects in a remotely sensed image are interpreted and digitized into a code based on the object's reflectance of bands of light.

The image codes are relayed through a satellite dish to a computer for storage or enhancement.

Image display is accomplished by conversion of stored data to a used-defined color-coded image.

Students become aware of land cover changes in their surroundings.

Scientific Enterprise

Computers have become invaluable in science.

Processes That Shape the Earth

Human activities have changed the land.

Scientific Inquiry Abilities

Develop predictions using evidence.

Propose an answer to a question using the land cover type map created.

Propose answers to questions about the system described.

Test the accuracy of land cover maps.

Scientists conduct investigations for a variety of reasons.

Usually there is no one right way to solve a problem.

Identify questions that can be answered by interpreting satellite images of the GLOBE Study Site.

Interpret satellite imagery in order to answer a question using MultiSpec software, a computer, and other appropriate tools and technologies.

Identify questions about the amount or type of change that has taken place in the GLOBE Study Site

Composite two images into one using MultiSpec software.

Draw pictures that correctly portray at least some of the features of the thing being described.

Communication involves coding and decoding.

Measuring
Classifying
Collecting data
Observing leaf growth.
Making leaf measurements.
Observing seasonal changes
Identify plant phenophases
Drawing conclusions about which factors can influence seasonal patterns.
Mapping data with GLOBE student Data Server to explore seasonal temperature patterns.
Graphing GLOBE data to show seasonal patterns.
Identify, age, and sex Ruby-throated Hummingbirds.
Count living, moving hummingbirds.
Plant and care for hummingbird habitats.
Planting and caring for shrubs
Identify flower and shrub species.
Estimate dominant plant species.
Identify plant species (advanced).
Discriminating among different factors that can affect ecosystem growth.
Tables, graphs, and symbols are alternative ways of representing data.
Use numerical data in describing and comparing objects and events.
Observe, interpret, and classify and image using the data given.
Analyze how the image interpretation might vary between groups.
Use numerical data for describing and comparing the accuracy of the data.

Hydrosphere

Earth and Space Science

Tides are caused by gravity.
Some soils can retain more water than other soils.

Physical Science

Water has characteristic properties such as density and solubility.

Life Sciences

The number of organisms a system can support depends on the resources available.

Geography

The physical characteristics of ecosystems are spatially distributed.

Scientific Inquiry Abilities

Use a chemical test kit to measure alkalinity.
Use a conductivity meter to measure conductivity of water.
Use a chemical test kit to measure dissolved oxygen.
Use a chemical test kit to measure nitrates.
Use a chemical test kit to measure salinity.
Use a hydrometer to measure salinity.
Use a thermometer to measure water temperature.
Use a transparency tube or Secchi disk to measure water transparency.
Use a chemical test strip or pH meter to measure pH.
Identify answerable questions.
Design and conduct scientific investigations.
Employ equipment, tools, to gather data and extend the senses.
Use appropriate mathematics to analyze data.
Develop descriptions and explanations using evidence.
Use data to construct a reasonable explanation.
Recognize and analyze alternative explanations.
Communicate procedures, investigations and explanations.

Soil (Pedosphere)

Earth and Space Science

Soils have properties such as color, texture, structure, consistence, density, pH, moisture, and heat that support the growth of many types of plants and serve numerous other functions in the ecosystem.

Life Science

Organisms can only survive in environments where their needs are met.
Earth has many different environments that support many different combinations of organisms.
All populations living together and the physical factors with which they

interact constitute an ecosystem.

Science in Personal and Social Perspective

Building materials are made from basic resources.

GPS

Earth and Space Science

Earth materials have different physical properties (magnetism).

Physical Science

The position of an object can be described by locating it relative to another object.

Materials have measurable properties (magnetism).

Science Concepts

Latitude and longitude determine location.

A compass may be used the Earth's magnetic field to give direction.

Levels of measurement incorporate degrees of accuracy.

There are mathematical techniques for characterizing the accuracy of a measurement.

Geography

Location is used to display information on maps.

Tools and technologies have distinct characteristics and capabilities.

Use appropriate geographic tools.

Latitude and longitude may be displayed on maps.

Science Inquiry Abilities

Use a magnetic compass to accurately determine angular direction.

Using a GPS receiver to determine latitude and longitude.

Use a compass to determine true north and south.

Identify answerable questions.

Design and conduct scientific investigations.

Develop descriptions and explanations using evidence.

Communicate procedures and explanations.

Use appropriate mathematics to analyze data.

Earth System Science

Scientific Inquiry Abilities

Identify answerable questions.

Generating questions and developing hypotheses.

Design and conduct scientific investigations.

Use appropriate tools and techniques.

Use appropriate mathematics to analyze data.

Recognize and analyze alternative explanations.

Develop descriptions, explanations, and predictions using evidence.

Use evidence to support conclusions.

Communicate procedures, descriptions, explanations, predictions, conclusions, and results.

Analyzing and interpreting results

Organizing observations in tables and graphs.

Representing information with pictures, numbers, and photographs.

Inferring

Hypothesizing predicting

Setting up and carrying out a simple investigation.

Sharing and comparing observations, predictions, and conclusions.

Communicating science concepts through diagramming.

Collaborate to develop a class project.

Observing patterns at different scales

Comparing across multiple variables

Presenting materials to a group.

Reading and interpreting maps.

Making maps.

Making graphs on the Internet.

Comparing graphs and analyzing data to determine the effects of latitude, elevation, and geographical features.

Comparing maps, graphs, and data tables as tools for data analysis.

Analyzing images of the Earth from space.

Modeling and analyzing three-dimensional relationships that vary in time.

Analyzing visualizations for important patterns.

Comparing and contrasting

visualizations.

Analyzing patterns in color visualizations.

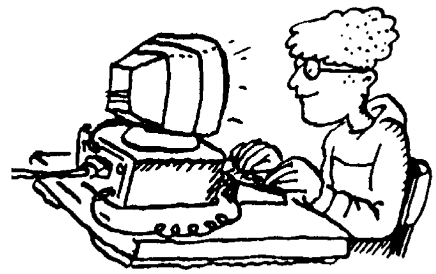
Assembling a three-dimensional model from a flat plane.

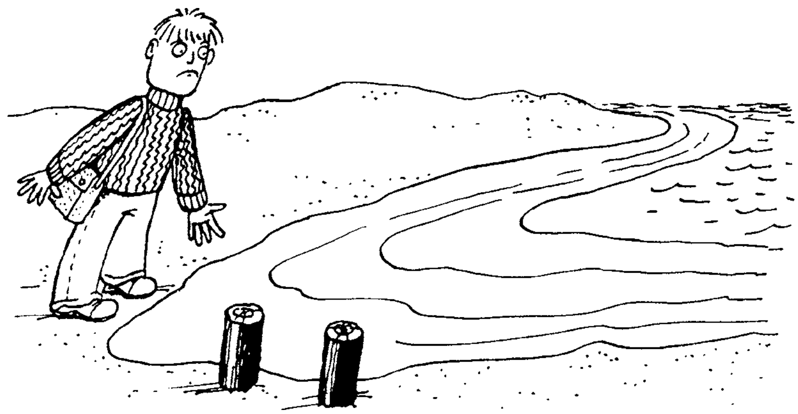
Analyzing global data sets displayed on maps.

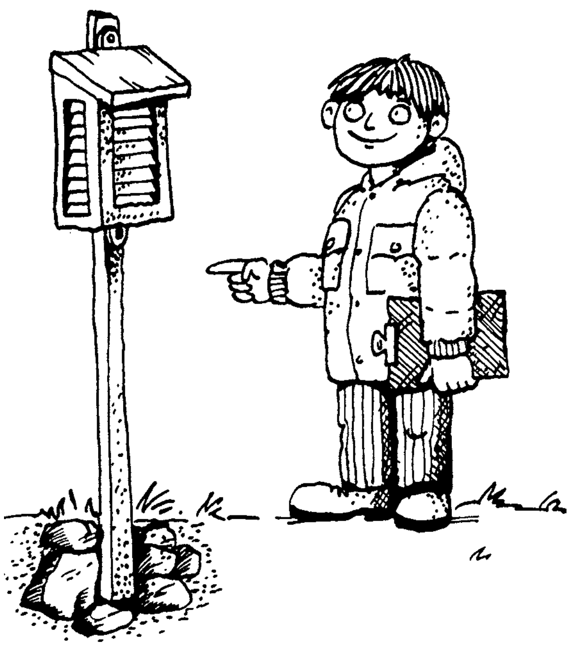
Observing the Earth system.

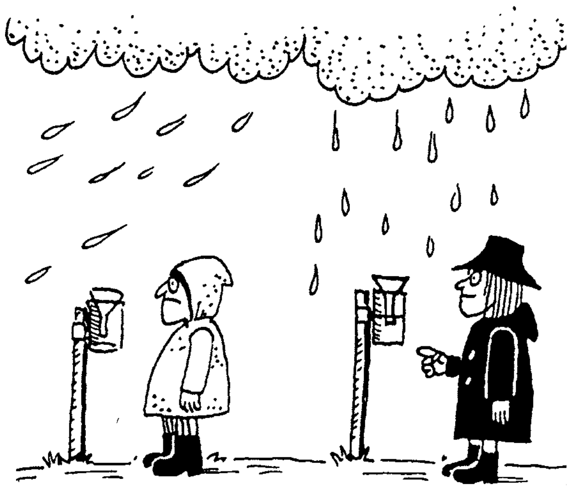
How to Upload Site Photos

Several GLOBE measurements provide the option for you to upload photos to the GLOBE database. This function is contained within the data entry pages of the GLOBE website.

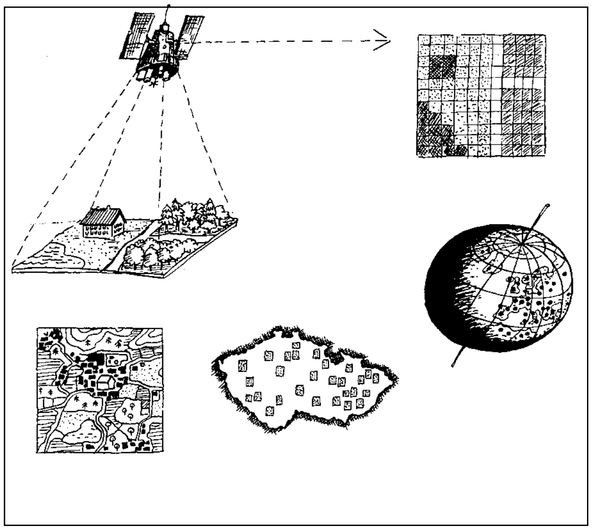


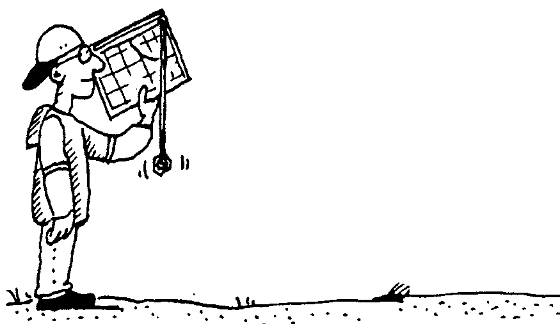


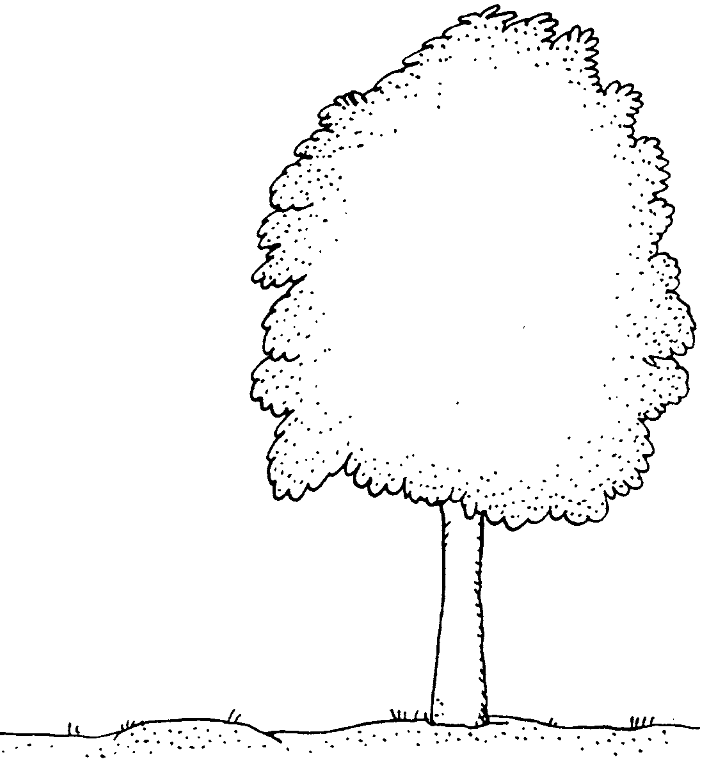


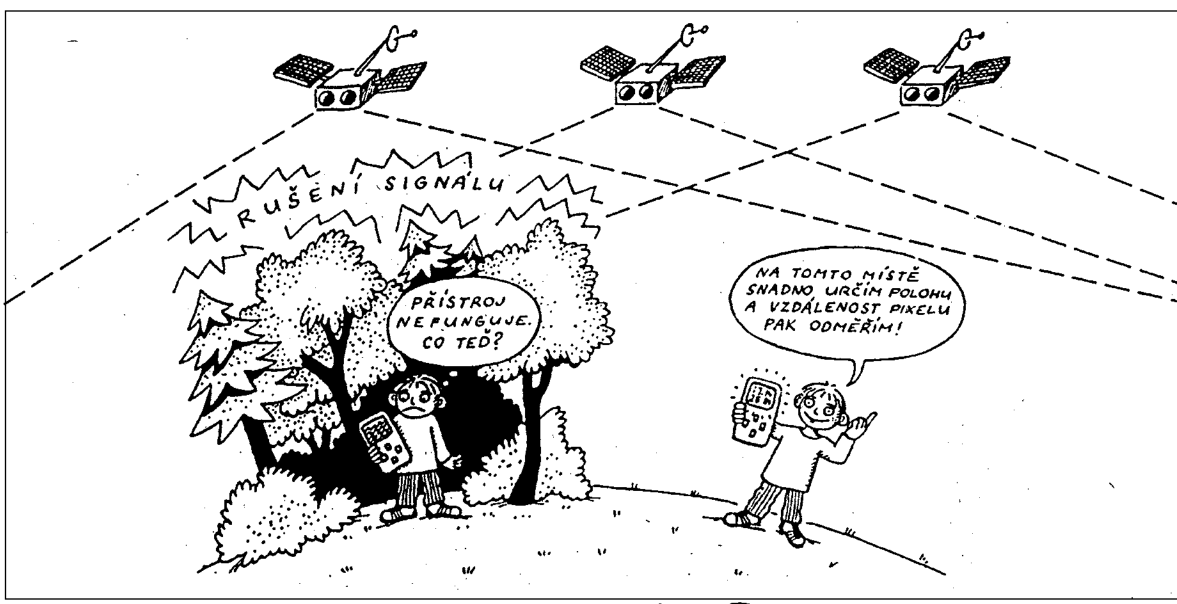


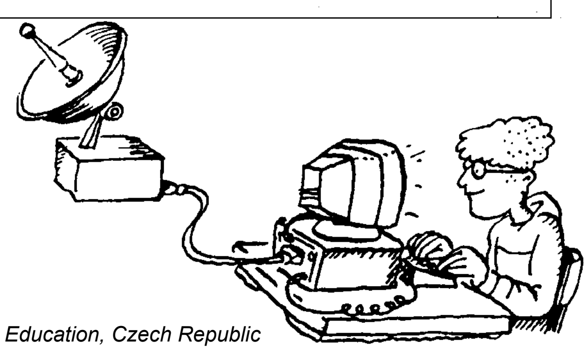
Source: Jan Smolík, 1996, TEREZA, Association for Environmental Education, Czech Republic











Source: Jan Smolík, 1996, TEREZA, Association for Environmental Education, Czech Republic