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HANDOUT 1 Igneous Fusion

Almost everyone has had the experience of being unable to answer a question involving recall when the question is stated in one form, and then having little difficulty…when the question is stated in another form. This is well illustrated by John Dewey's story in which he asked a class, "What would you find if you dug a hole in the Earth?" Getting no response, he repeated the question; again he obtained nothing but silence. The teacher chided Dr. Dewey, "You're asking the wrong question." Turning to the class, she asked, "What is the state of the center of the Earth?" The class replied in unison, "igneous fusion."

Understanding by Design (2005) p. 47-48

Original Source: Bloom (1956) *A Taxonomy of Educational Objectives: Classification of Educational Goals, p. 29*

HANDOUT 2 Igneous Fusion Reflection

Name: _____ Date: _____

What does this scenario reveal to you about the nature of student understanding and the teaching of Earth science?

What do you think understanding really is?

HANDOUT 3 Earth Science by Design Essential Questions

- How do we teach for *understanding* in Earth system science?

- How do we design appropriate *assessments* to evaluate understanding in Earth system science?

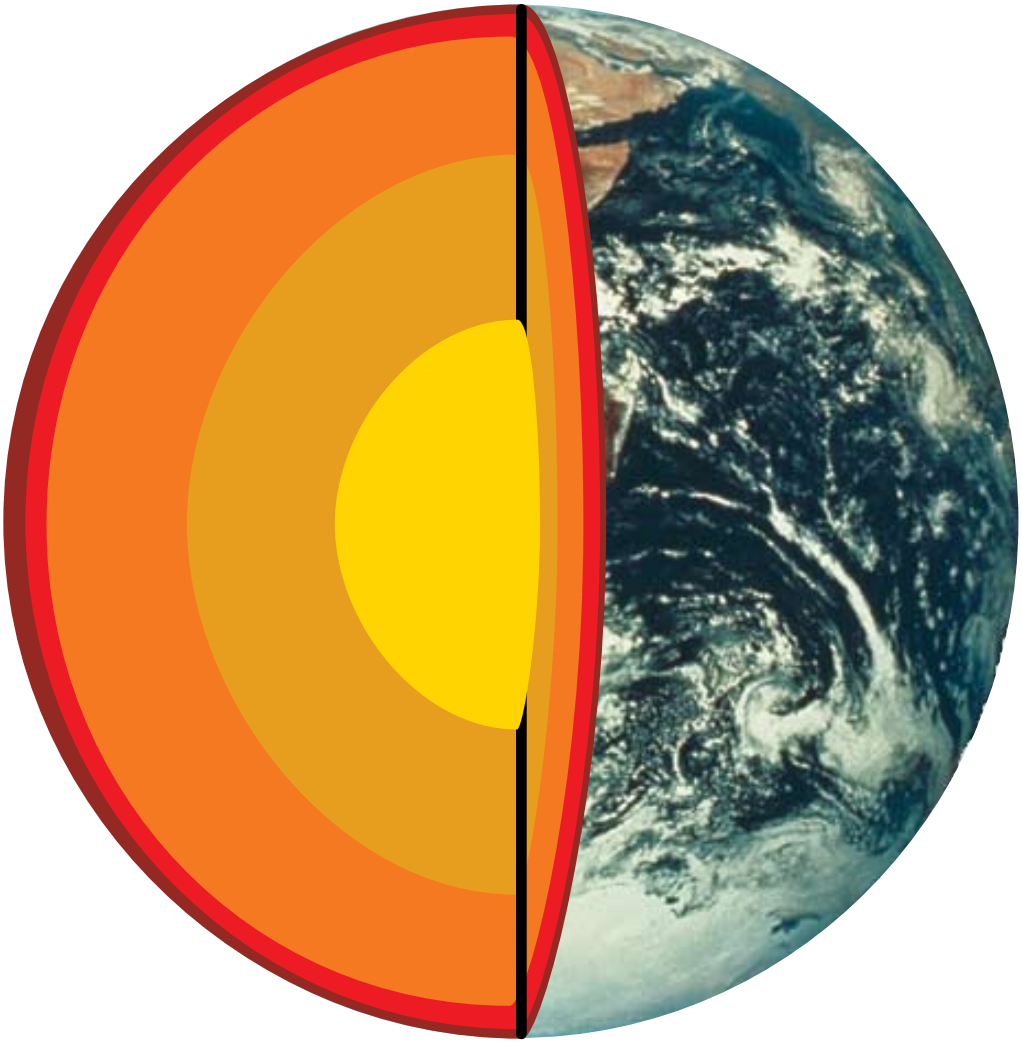
- How do we move students from their strongly held *misconceptions* toward more enduring understandings in Earth system science?

- How do we use scientific *visualization*s to build understanding in Earth system science?

- How do we use *reflection* to understand and improve teaching?

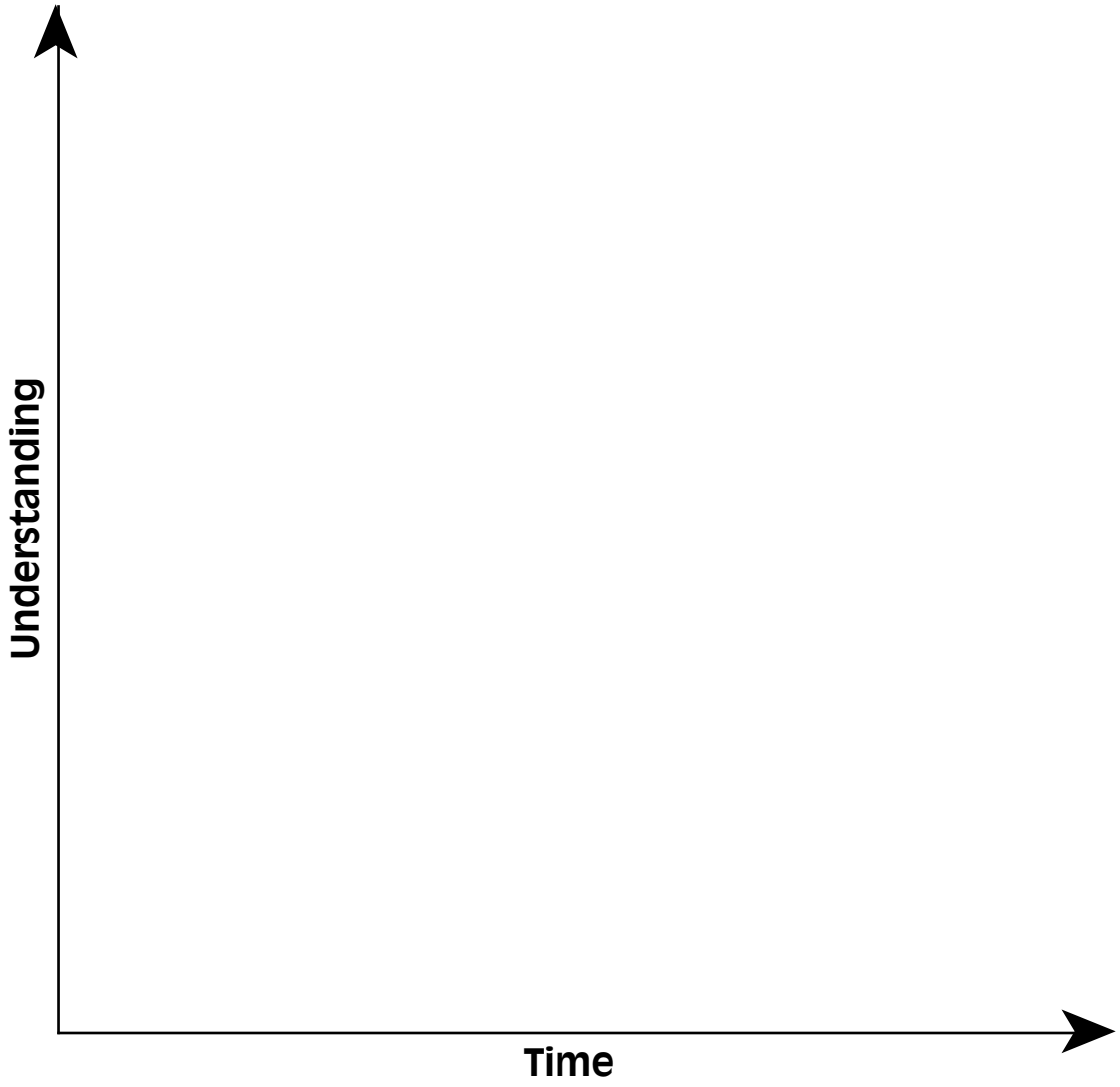
- What are the characteristics of an *Earth Science by Design* teacher?

HANDOUT 4 The Layers of the Earth

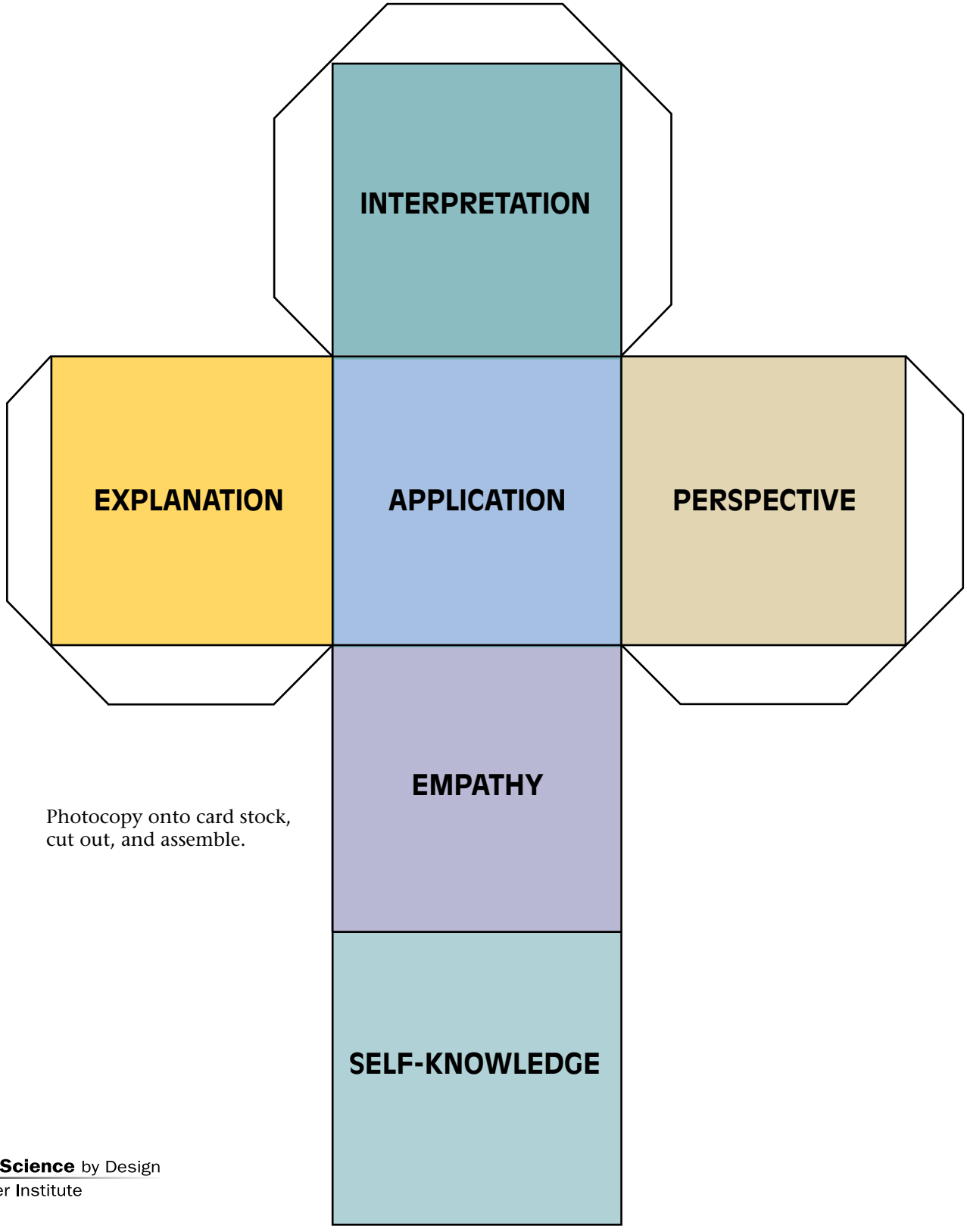


Do our students *really* have a *deep* and *enduring* understanding of the dynamic nature of the interior structure of the Earth and its implications for planet Earth?

HANDOUT 5 A Graph of Understanding Over Time



HANDOUT 6 Understanding Cube



Photocopy onto card stock, cut out, and assemble.

HANDOUT 7 Reviewing The Six Facets of Understanding

Definitions from Understanding by Design

Explanation

Sophisticated and apt understandings and theories, which provide knowledgeable and justified accounts of events, actions, and ideas.

Interpretation

Narratives and translations that provide meaning.

Application

The ability to use knowledge effectively in new situations and diverse contexts.

Perspective

Critical and insightful points of view.

Empathy

The ability to identify with another person's feelings or worldviews.

Self-Knowledge

The wisdom to know one's ignorance and how one's patterns of thought and action inform as well as prejudice understanding.

HANDOUT 8 The Six Facets of Understanding

Mt. St. Helens Eruption Example:

Explanation

Explain why Mt. St. Helens erupted. Extend this explanation to include other volcanoes in the Cascades.

Interpretation

What is the geologic story of Mt. St. Helens? How has the volcano changed over time?

Application

Apply your understanding of the Mt. St. Helens eruption to make predictions of other places in the world where similar eruptions might occur.

Perspective

Examine the role volcanoes play in Earth Systems.

Empathy

Why do people choose to live near volcanoes?

Self-Knowledge

How well do you understand volcanic eruption?

HANDOUT 9 Applying the Six Facets of Understanding

Explanation

Interpretation

Application

Perspective

Empathy

Self-Knowledge

HANDOUT 10 Reflection Day 1 Morning

Name: _____ Date: _____

Reflect on the morning's activities about the nature of understanding. Which facets do you most often use to assess student understanding in your classroom? If there is a facet that you have not used but would like to investigate further, please name it and tell why you think it would provide insights into student learning in Earth science.

HANDOUT 11 Earth Science Concepts for "What is Worthy of Understanding?"

(Answer Key for Leaders)

Classified by Sphere and by Curricular Importance

1 = Worthy of Deep Understanding
2 = Important to Know and Do
3 = Worth Being Familiar With

Atmosphere

1 – Solar radiation drives the atmosphere, causing winds and powering the hydrologic cycle.

1 – The atmosphere is a mixture of gases and suspended solids and liquids.

1 – The atmosphere exhibits long-term circulation patterns and short-term patterns known as weather-storms, hurricanes, and tornadoes.

2 – Clouds are formed when a rising then cooling air mass reaches the dew point.

2 – Weather instruments are used to measure elements of weather such as temperature, air pressure, precipitation, and wind speed.

2 – Air has mass and for this reason has other properties including pressure and density.

3 – To find ˚F, multiply ˚C by 1.8, then add 32.

3 – The Earth's atmosphere is .03% CO_2.

3 – Lines of equal pressure on a weather map are called isobars.

Biosphere

1 – Human beings have a unique, large, and growing impact on the Earth's biosphere.

1 – Environmental change can cause extinction or lead to the evolution of a species.

1 – Life affects the composition of the atmosphere, weathering, the carbon cycle, and the rock cycle.

• A species is a population of organisms that are able to interbreed and produce fertile offspring.

2 – Many different kinds and numbers of organisms have existed at various times during Earth's history.

2 – There are two kinds of natural resources, renewable and nonrenewable.

3 – An asteroid impact probably caused the extinction of the dinosaurs 65 million years ago.

3 – Anthracite coal is an important natural resource.

3 – Soils are made of layers called horizons.

Space Science

1 – The relative positions of the sun, Earth, and moon account for the phases of the moon.

1 – The seasons are caused by the relative position of the Earth's axis as it revolves around the sun.

HANDOUT 11 Earth Science Concepts for "What is Worthy of Understanding?" Activity - Page 2

1 – The Earth is just one planet in a solar system, in a galaxy filled with billions of stars, in a universe of billions of other galaxies.

2 – Galaxies are large assemblages of different types of stars.

2 – Lunar and solar eclipses are created by particular (and rare) alignments of the sun and moon.

2 – When the moon is full or new, neap and spring tides can be expected.

2 – The scale relationships of the Earth, sun and moon are important for the understanding of astronomical events and processes.

3 – The Earth has a very slight elliptical orbit (almost a perfect circle).

3 – When only a part of the sun is covered by the moon during a solar eclipse, it is called a partial eclipse.

3 – A light year is about 6 trillion miles.

Geosphere

1 – The movement of lithospheric plates causes slow changes in the Earth's surface (mountains, ridges, ocean basins).

1 – The Earth's surface is built up and worn down by natural processes, such as rock formation, erosion, and weathering.

2 – Fossils and radioactive dating provide evidence used to interpret Earth's evolution.

2 – Over millions of years the continuous movement of the Earth's crust causes the continents to merge and divide repeatedly.

2 – Most of the world's earthquake and volcanoes occur at the boundaries of lithospheric plates.

3 – Superposition helps us determine the sequence of geologic events.

3 – The action of freezing and thawing that breaks down the surface of rocks is called frost wedging.

3 – The pattern of volcanic activity around the Pacific basin is called the "Ring of Fire."

Hydrosphere

1 – Circulation patterns in the oceans are driven by density differences and wind.

1 – Water cycles through the atmosphere, hydrosphere, geosphere, and biosphere.

2 – Large canyons, mountains, and long ridges can be found on the floor of Earth's oceans.

2 – The Gulf Stream causes local and regional climate variations in different parts of the world.

3 – The West Wind Drift near Antarctica is a global current.

3 – The salinity of Earth's oceans is roughly constant over time.

HANDOUT 12 Earth Science Concepts for "What is Worthy of Understanding?"

Unclassified

Print several sheets of these (one-sided) and cut apart individual concepts with a paper cutter. Give one complete set to each small group of teachers.

Solar radiation drives the atmosphere, causing winds and powering the hydrologic cycle.

The atmosphere is a mixture of gases and suspended solids and liquids.

The atmosphere exhibits long-term circulation patterns and short-term patterns known as weather: storms, hurricanes, and tornadoes.

Clouds are formed when a rising then cooling air mass reaches the dew point

Weather instruments are used to measure elements of weather such as temperature, air pressure, precipitation, and wind speed.

Air has mass and for this reason has other properties including pressure and density.

To find ˚F, multiply ˚C by 1.8, then add 32.

The Earth's atmosphere is .03% CO_2.

Lines of equal pressure on a weather map are called isobars.

Human beings have a unique, large, and growing impact on the Earth's biosphere.

Environmental change can cause extinction or lead to the evolution of a species.

Life affects the composition of the atmosphere, weathering, the carbon cycle, and the rock cycle.

HANDOUT 12 Earth Science Concepts for "What is Worthy of Understanding?" Activity - Page 2

A species is a population of organisms that are able to interbreed and produce fertile offspring.

Many different kinds and numbers of organisms have existed at various times during Earth's history.

There are two kinds of natural resources, renewable and nonrenewable.

An asteroid impact probably caused the extinction of the dinosaurs 65 million years ago.

Anthracite coal is an important natural resource.

Soils are made of layers called horizons.

The relative positions of the sun, Earth, and moon account for the phases of the moon.

The seasons are caused by the relative position of the Earth's axis as it revolves around the sun.

The Earth is just one planet in a solar system, in a galaxy filled with billions of stars, in a universe of billions of other galaxies.

Galaxies are large assemblages of different types of stars.

Lunar and solar eclipses are created by particular (and rare) alignments of the sun and moon.

When the moon is full or new, neap and spring tides can be expected.

The scale relationships of the Earth, sun and moon are important for the understanding of astronomical events and processes.

The Earth has a very slight elliptical orbit (almost a perfect circle).

When only a part of the sun is covered by the moon during a solar eclipse, it is called a partial eclipse.

HANDOUT 12 Earth Science Concepts for "What is Worthy of Understanding?" Activity - Page 3

A light year is about 6 trillion miles.

The movement of lithospheric plates causes slow changes in the Earth's surface (mountains, ridges, ocean basins).

The Earth's surface is built up and worn down by natural processes, such as rock formation, erosion, and weathering.

Fossils and radioactive dating provide evidence used to interpret Earth's evolution.

Over millions of years the continuous movement of the Earth's crust causes the continents to merge and divide repeatedly.

Most of the world's earthquake and volcanoes occur at the boundaries of lithospheric plates.

Superposition helps us determine the sequence of geologic events.

The action of freezing and thawing that breaks down the surface of rocks is called frost wedging.

The pattern of volcanic activity around the Pacific basin is called the "Ring of Fire."

Circulation patterns in the oceans are driven by density differences and wind.

Water cycles through the atmosphere, hydrosphere, geosphere, and biosphere.

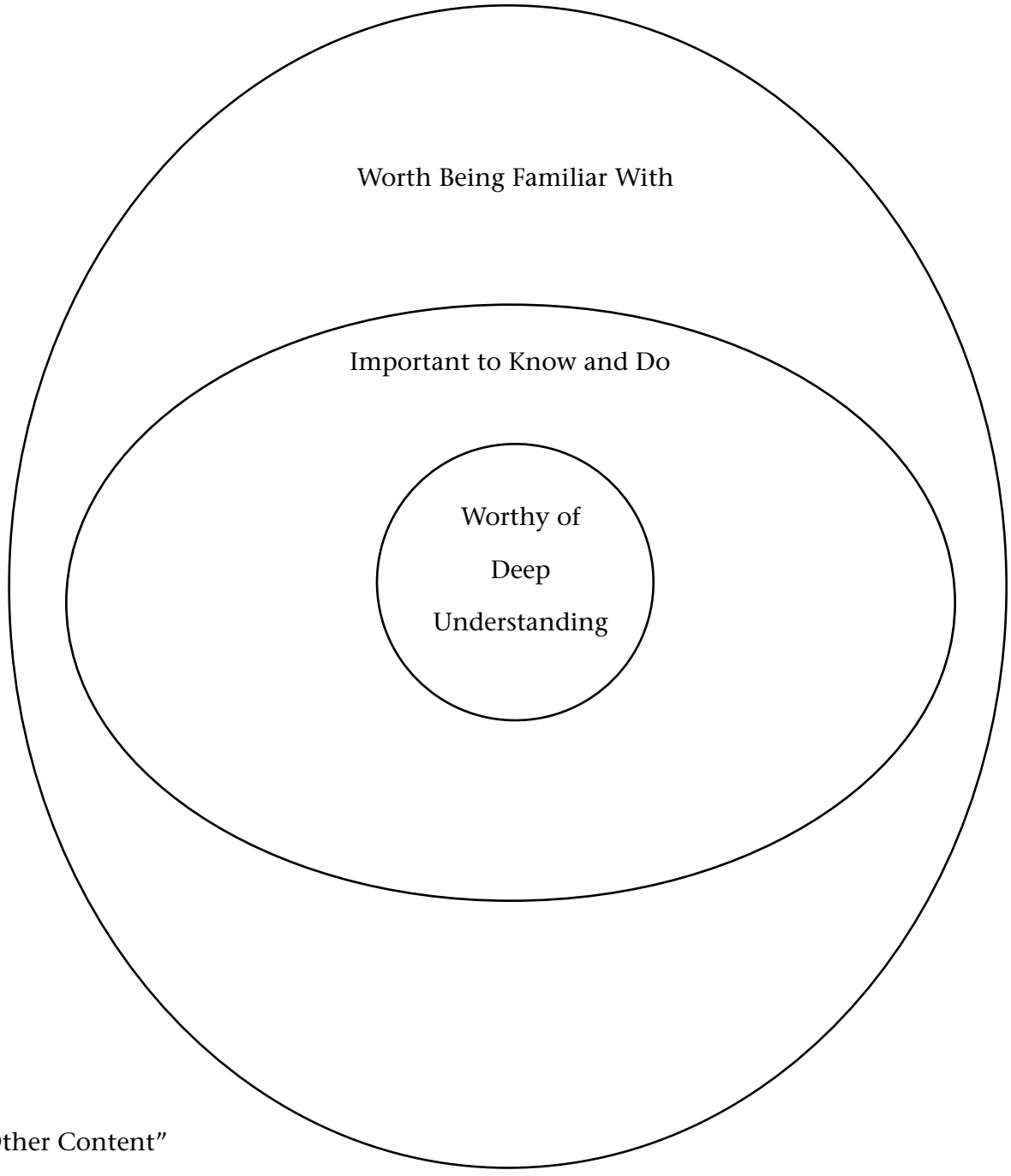
Large canyons, mountains, and long ridges can be found on the floor of Earth's oceans.

The Gulf Stream causes local and regional climate variations in different parts of the world.

The West Wind Drift near Antarctica is a global current.

The salinity of Earth's oceans is roughly constant over time.

HANDOUT 13 The Classification of Curricular Knowledge



Based on *Understanding by Design*, Wiggins and McTighe, 2005, ASCD.

HANDOUT 14 Filters for Enduring Understanding

Use these filters to determine if an idea, concept, or process is worthy of deep understanding. If you can answer "yes" to each of these questions, then it is.

1. Does the idea have enduring value over time?

2. Does the idea reside at the heart of the discipline?

3. Is the idea rich in meaning, integrative, complex, and in need of uncoverage to be understood?

4. Does the idea help the student organize and make sense of the content?

HANDOUT 15 The Big Ideas in Earth and Space Science

The Earth System

1. Earth can be conceived as an interacting set of processes and structures composed of the atmosphere, geosphere, hydrosphere, and biosphere.
2. Radiation, conduction, and convection transfer energy through Earth's systems.

The Geosphere

3. The geosphere includes the lithosphere, the mantle, and the dense metallic cores.
4. The surface of Earth has identifiable major features—land masses (continents), oceans, rivers, lakes, mountains, canyons, and glaciers
5. The movement of Earth's lithospheric plates causes both slow changes in the Earth's surface (e.g., formation of mountains and ocean basins) and rapid ones (e.g., volcanic eruptions and earthquakes).
6. Earth's surface is built up and worn down by natural processes, such as rock formation, erosion, and weathering.
7. Physical evidence, such as fossils and radioisotopic dating, provide evidence for the Earth system's evolution and development.

The Atmosphere

8. The atmosphere is a mixture of gases with suspended solids and liquids.
9. Radiant energy from the sun creates temperature differences in water, land, and the atmosphere which drive local, regional, and global patterns of atmospheric circulation.
10. The atmosphere exhibits long-term circulation patterns (climate) and short-term patterns known as weather—storms, hurricanes, and tornadoes.

The Hydrosphere

11. Water cycles through the atmosphere, hydrosphere, geosphere, and biosphere.
12. Circulation patterns in the oceans are driven by density differences and by exchange of momentum with the atmosphere.
13. Liquid water in great abundance makes Earth unique among the planets of the solar system.

The Biosphere

14. Life is pervasive throughout the Earth system—in the atmosphere, the hydrosphere, and the upper lithosphere.
15. Life appeared early in Earth's history and is intimately involved in the nature of Earth—i.e. composition of the atmosphere, weathering, carbon cycle, and rock cycle.
16. The biosphere both shapes and is shaped by the physical environment.
17. Human beings have a unique, large, and growing impact on Earth systems.

Space Science

18. Earth exists in the solar system, in the Milky Way galaxy, and in the universe, which contains many billions of galaxies.
19. The sun, Earth, and the other planets were formed in a few hundred million years between four and five billion years ago.
20. The relative position and movements of Earth, the moon, and sun account for day and night, lunar and solar eclipses, the observed moon phases, tides, and seasons.

The Nature of Earth Science

21. Earth scientists use representations and models, such as contour maps and satellite images to help them understand Earth systems.
22. Scientists use quantitative, qualitative, experimental and other methods of investigation to understand Earth.
23. Earth scientists make an assumption of uniformitarianism, that the processes that shaped Earth in the past are the same processes we observe today.
24. Technological advances, such as seismic sounding and satellite remote sensing, advance Earth science knowledge.
25. As in all scientific disciplines, knowledge in Earth science is subject to revision.

HANDOUT 16 An Introduction to Earth System Science

Guiding Questions for Small Groups:

Activity 1 – Exploring a Single Map

- What is the range of values shown on the scale bars on each card?
- Where in the world do you find the highest and lowest values of the data on your map? Where are the extremes? Why are the extremes in these locations and not somewhere else?
- Do you see any patterns? Are they different on different continents? Different over water than over land? How do you explain these patterns?

Activity 2– Exploring Annual Changes in a Measurement

- What changes do you see through the year? What seasonal changes and annual cycles emerge? What explanations can you suggest for these patterns?
- Pick a location or area. During which months do the extreme highs and lows occur for each measurement? What explanations can you suggest for the timing of those extremes?
- Which regions experience the extreme highs and lows for each measurement? Which regions don't experience the extremes? Why do you think this is so?
- What differences, if any, do you find between the year's variations over the oceans versus the year's variations over the continents?
- Are there regions that remain unchanged over the year? Why do you think this is so?

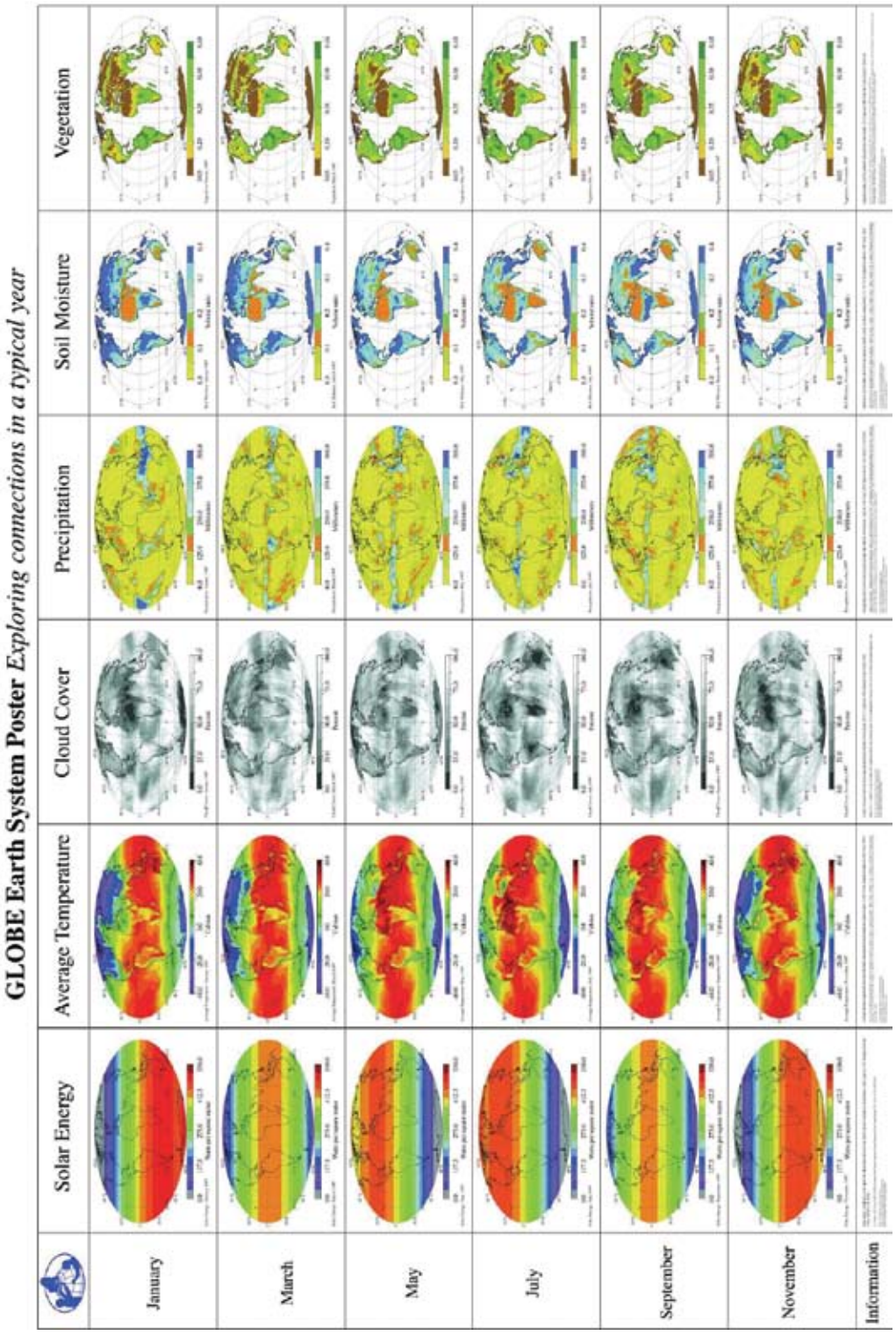
Activity 3 – Exploring Relationships Between Two Types of Measurements

- What relationship do you see between solar energy and average temperature? Cloud cover and precipitation? Soil Moisture and Vegetation?
- Are the relationships proportional or inverse?

Activity 4 – What is Earth System Science?

- What are the parts of the Earth system that you examined during the activities?
- Which of these parts has to do with Earth's matter? Which of these parts has to do with Earth's energy? Which of these parts has to do with Earth's life?
- How do the parts work together to create the Earth system as a whole?
- Which of the parts can be considered a closed system, which ones can be considered open systems?
- What are the parts of each of the smaller systems that you examined in this activity?

HANDOUT 17 GLOBE Earth System Poster



HANDOUT 18 Reflection Day 1 Afternoon

Name: _____ Date: _____

What is the main understanding that you struggled with today?

Please share any insights that you gained today about teaching and learning.

Please share any thoughts about the activities that you felt were particularly helpful or confusing. Be as specific as possible.

HANDOUT 19 ESBD Unit Planner

Title:

Author:

School:

Stage 1: Identify Desired Results

Unit Description:

Relationship to the Big Ideas in Earth Science:

Unit Enduring Understandings:

Unit Essential Questions:

What students will need to know and be able to do (knowledge and skills):

What students typically misunderstand:

HANDOUT 19 ESBD Unit Planner - Page 2

Stage 2: Determine Acceptable Evidence

Describe the authentic performance assessment in terms of GRASPS.

G

What is the Goal of the performance?

R

What Role does the student assume in the performance?

A

What Audience does the student address?

S

What is the Situation for the performance?

P

What Product should be produced?

S

What are the Standards for the product?

HANDOUT 19 ESBD Unit Planner - Page 3

Preconceptions Survey:

Describe how determine students' pre-existing level of understanding before you begin the unit.

Quizzes, Tests, and Academic Prompts:

Describe any quizzes, test, or academic prompts you will use to assess students' understanding.

Other Assessment Evidence:

Describe any other evidence you will use to assess student understanding, e.g. portfolios, class discussions

Stage 3: Plan Learning Experiences, Instruction, and Resources

Use "WHERETO" as a guide to describe the sequence of learning experiences, instructional strategies, and resources you will use to help students address the essential questions of the unit and achieve deep understanding of the big ideas.

HANDOUT 19 ESBD Unit Planner - Page 4

W

How will you help students know *where* they are headed in this unit and *why* and what are the major assignments, performance tasks, and criteria by which the work will be judged)?

H

How will you *hook* students through engaging and thought-provoking experiences (e.g., issues, oddities, problems, and challenges) that point toward big ideas, essential questions, and performance tasks?

E

What events, real or simulated, can students *experience* to make the ideas and issues real? What learning activities will help students to *explore* the big ideas and essential questions? What instruction is needed to *equip* students for the final performances?

R

How will you cause students to *reflect* and *rethink* to dig deeper into the core ideas? How will you guide students in *rehearsing, revising,* and *refining* their work based on feedback and self-assessment?

E

How will students *exhibit* their understanding about their final performances and products? How will you guide them in self-*evaluation* to identify the strengths and weaknesses in their work and set future goals?

T

How will you *tailor* and differentiate instruction to accommodate your student's developmental needs, learning styles, prior knowledge, and interests?

O

How will you *organize* a sequence of learning experiences that will best develop and deepen student understanding, while minimizing likely misconceptions?

HANDOUT 20 The Rock Cycle in the NSES

"Some changes in the solid Earth can be described as the 'rock cycle.' Old rocks at the Earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues."

National Science Education Standards (1996), Content Standard D, grades 5-8, p. 160.

HANDOUT 21 Understandings for The Rock Cycle

List the 2-4 understandings that your group selected for the Rock Cycle unit . (They must have passed four screening questions.)

1.

2.

3.

4.

Group Members _____

_____

_____

HANDOUT 22 Characteristics of Essential Questions

In their book *Understanding by Design* (2005), Grant Wiggins and Jay McTighe develop the concept of essential questions. Here is a short summary of the nature and purpose of essential questions:

- Essential questions help guide teaching and learning.
- They engage students (so they must be interesting!)
- They should not have easy, quick, or obvious answers.
- They should not be able to be answered with a simple factual statement.
- They should require and invite elaboration.
- They may be counter-intuitive.
- They may be provocative.
- They may force a change of perspective.
- They may encourage empathy.
- Teachers and students should return to them over and over during the course of their study on a topic.
- Essential questions should be "provocative and multilayered questions that reveal the richness and complexities of a subject".
- They point to the "key inquiries and the core ideas of a discipline".
- Essential questions should raise other important questions.

HANDOUT 23 Essential Questions for The Rock Cycle

List the 2-4 essential questions for the Rock Cycle that your group selected.

1.

2.

3.

4.

Group Members _____

_____

_____

_____

HANDOUT 24 Knowledge and Skills for The Rock Cycle

List the key knowledge and skills that students will need in order to answer the essential questions and attain the understandings that have been identified for the Rock Cycle unit.

1.

2.

3.

4.

5.

Group Members _____

Date _____

HANDOUT 25 Potential Misunderstandings for The Rock Cycle

List the potential preconceptions and misconceptions that students may have before they begin to study the Rock Cycle.

1.

2.

3.

4.

5.

6.

7.

8.

HANDOUT 26 Reflection Day 2 Morning

Name:_____ Date: _____

What difficulties did you encounter while developing understandings for the Rock Cycle Unit?

Argue the case that "What is a rock" is an essential question. Now, argue the case that "What is a rock" is **not** an essential question.

HANDOUT 27 ESBD Six Design Filters for Assessment

We use six design filters, or criteria, to determine the adequacy of the assessments created for an ESBD unit. The first four criteria apply to each and every assessment; the fifth criterion applies only to the performance assessment; the sixth criterion applies to the suite of assessments taken together.

Each *individual* assessment should be:	✔ **Valid**
	✔ **Reliable**
	✔ **Feasible**
	✔ **Student-friendly**
The *performance* assessment should also be:	✔ **Authentic**
Taken together, the *suite* of assessments should be:	✔ **Sufficient**

to "convict" the student of understanding "beyond a reasonable doubt."

HANDOUT 28 GRASPS Template Example

Unit Title: Volcanic Eruptions
Use this template to develop the vignette you will write to describe the authentic performance assessment to your students.

Goal

What is your goal?
To reduce the loss of life and property damage by accurately predicting when, and to what extent, a volcanic eruption might affect Mt. Shasta.

Role

What is your role?
You are an urban planner.

Audience

Who is your audience?
Present your plan to the city council.

Situation

What is the situation?
You have been asked to develop and present a risk assessment and mitigation plan for the city of Mt. Shasta.

Product

What should you produce?
Prepare a PowerPoint presentation that includes a map and other supporting visuals. Generate slide pages for the audience.

Standards

What are the standards for your product?
Your presentation should:

- inform the city council by telling the geologic story of Mt. Shasta
- include a research-based prediction of when the next eruption might occur.
- contain a map of the areas most likely to be affected by an eruption along with other visuals that support the presentation.
- include an emergency response plan based on the predicted flow of the path of the lava.
- be clear, persuasive, and scientifically accurate.

HANDOUT 28A Authentic Performance Assessment Sample Vignette

Performance Task for Volcanic Eruptions Unit

You are an urban planner with the city of Mt. Shasta in California. You have been asked to develop and present a risk assessment and mitigation plan in the event that Mt. Shasta erupts. You hope to reduce the loss of life and property damage by accurately predicting when, and to what extent, a volcanic eruption might affect Mt. Shasta. You will need to prepare a plan that you present to the city council. Present your plan in the form of a PowerPoint presentation. Be sure to inform the city council with critical background information by telling the geologic story of Mt. Shasta. Include a research-based prediction of when the next eruption might occur. Prepare a map that shows the areas most likely to be affected by an eruption. Describe your emergency response plan based on the predicted flow of the path of the lava. In addition to maps, it is fine to use additional visuals as needed, as long as they support the presentation. Your presentation should be clear, persuasive, and scientifically accurate.

HANDOUT 29 GRASPS Template

Unit Title:
Use this template to develop the vignette you will write to describe the authentic performance assessment to your students.

Goal	**What is your goal?**
Role	**What is your role?**
Audience	**Who is your audience?**
Situation	**What is the situation?**
Product	**What should you produce?**
Standards	**What are the standards for your product?**

HANDOUT 30 Criterion List for Science Lab Report

5 pts	Research Question
5 pts	Hypothesis
10 pts	Experimental Procedure
20 pts	Analysis
20 pts	Conclusion
60 pts	Total

Handout 30A Holistic Rubric for Science Lab Report

5 Highly Proficient	4 Capable	3 Adequate	2 Limited	1 Inadequate
The lab report contains the five required sections (i.e. research question, hypothesis, experimental procedure, analysis, conclusion). The research question is sophisticated. The hypothesis is refutable and directly relates to the research question. The experimental procedure is logical and can be replicated. Analyses are comprehensive and appropriately carried out. All conclusions are thorough, insightful, and fully supported by the analyses. The report thoughtfully conveys the ideas and all scientific information is accurate.	The lab report contains the five required sections (i.e. research question, hypothesis, experimental procedure, analysis, conclusion). The research question is revealing. The hypothesis is refutable and directly relates to the research question. The experimental procedure is logical and can be replicated. Meaningful analyses have been appropriately carried out. All conclusions are fully developed and supported by the analyses. The report clearly conveys the ideas and all scientific information is accurate.	The lab report contains the five required sections (i.e. research question, hypothesis, experimental procedure, analysis, conclusion). The research question is in-depth. The hypothesis is refutable and directly relates to the research question. The experimental procedure consists of steps that can mostly be replicated. Appropriate analyses have been carried out. All conclusions are fully supported by the analyses. The report systematically conveys the ideas but contains a few minor scientific inaccuracies.	A major section of the lab report is missing or some sections are incomplete (i.e. research question, hypothesis, experimental procedure, analysis, conclusion). The research question is somewhat developed. The hypothesis is refutable and somewhat relates to the research question. The experimental procedure is missing steps that make it difficult to replicate. Analyses have been carried out, but may not be appropriate or needed. Conclusions are not fully supported by the analyses. The report incompletely conveys the ideas and contains some serious scientific inaccuracies.	Two or more major sections of the lab report are missing or most sections are incomplete (i.e. research question, hypothesis, experimental procedure, analysis, conclusion). The research question is naive. The hypothesis is not refutable or does not directly relate to the research question. The experimental procedure is illogical and cannot be replicated. Limited analyses have been carried out, but may not be appropriate or needed. Conclusions are irrelevant and do not support the analyses. The report superficially conveys the ideas and most scientific information is inaccurate.

HANDOUT 30B Analytic Rubric for Science Lab Report

	5 Highly Proficient	4 Capable	3 Adequate	2 Limited	1 Inadequate
Completeness of the Report	All five required sections present	All five required sections present	All five required sections present	A major section missing or some sections incomplete	Two or more major sections missing or some sections incomplete
Quality of the Research Question	Sophisticated	Revealing	In-depth	Somewhat developed	Naive
The Nature of the Hypothesis	Refutable and relates to research question	Refutable and relates to research question	Refutable and relates to research question	Refutable and somewhat relates to research question/OR/Not refutable, but relates	Not refutable or does not relate to research question
The Experimental Procedure	Logical and replicable	Logical and replicable	Consists of steps that can mostly be replicated	Missing steps that make it difficult to replicate	Illogical and cannot be replicated
Analyses	Comprehensive and appropriately carried out	Meaningful and appropriately carried out	Appropriate and carried out	Carried out, but may not be appropriate or needed	Limited analyses that may not be appropriate or needed
Quality of Conclusions	Thorough, insightful, fully supported	Fully developed and supported	Fully supported	Not fully supported	Irrelevant; not supported
Expression of Ideas	Thoughtful	Clear	Systematic	Incomplete; fragmented	Superficial
Spelling and Grammar	No spelling or grammar mistakes	Limited spelling and grammar mistakes	Spelling and grammar mistakes do not interfere with readability	Spelling and grammar mistakes distract from readability	Spelling and grammar mistakes too numerous to count
Scientific Accuracy	Accurate	Accurate	Contains a few minor inaccuracies	Contains some serious inaccuracies	Mostly inaccurate

HANDOUT 31 Volcanic Eruptions Rubric Construction

Attributes	5 Highly Proficient	4 Capable	3 Adequate	2 Limited	1 Inadequate	Weight
Geologic story	Comprehensive story that is scientifically accurate	Revealing story that is scientifically accurate	Complete and scientifically accurate	Missing some content but scientifically accurate	Incomplete and scientifically inaccurate	
Eruption prediction supported by evidence	All evidence clearly supports prediction	All evidence clearly supports prediction	All evidence clearly supports prediction	Some evidence supports the prediction	Evidence does not support prediction	
Emergency Response Plan	Insightful	Thorough	Considered	Aware	Unaware	
Maps and Visuals	Support and are integral to the presentation	Fully support the presentation	Mostly support the presentation	Have limited value; connected only loosely to the presentation	Used decoratively	
Expression of Ideas	Thoughtful	Clear	Systematic	Incomplete; fragmented	Superficial	
Spelling and Grammar	No spelling or grammar mistakes	Limited spelling and grammar mistakes	Spelling and grammar mistakes do not interfere with readability	Spelling and grammar mistakes distract from readability	Spelling and too numerous to count	

HANDOUT 31A Assessment 1: Mystery Planet

An application of the geological evidence of continental drift

Mystery Planet-An application of the geological evidence of plate tectonics.
Goal: Students will reconstruct a super continent from individual continents located on an imaginary planet, which has the same tectonic activity as Earth, using fossil, mineral, mountain evidence.

Situation: Students will be given geologic data on "maps" of the mystery continents. Using the evidence on the maps students will arrange the continents into a super continent. Students will also be expected to explain how the evidence supports their arrangement of the continents and how the evidence showing the previous arrangement of the continents supports the theory of plate tectonics.

Product: A completed map with the continents arranged according to the evidence given and an essay explaining how they used the evidence to solve the puzzle and how it relates to the theory of plate tectonics.

Rubric

	5	4	3	2	1
Grammar and Spelling	Few or no spelling and grammar mistakes	Spelling and grammar mistakes somewhat distracting to reader	Spelling and grammar mistakes distracting to reader	Spelling and grammar mistakes very distracting to reader	Spelling and grammar mistakes too numerous to mention
Accuracy of final map	Evidence transferred expertly and continents arranged correctly	Evidence transferred accurately and continents arranged correctly	Some evidence not transferred accurately but continents arranged adequately	Evidence not transferred accurately or continents arranged incorrectly	Evidence not transferred accurately and continents arranged incorrectly
Use of evidence to reconstruct the super continent	Evidence used expertly to reconstruct the super continent	All evidence used to reconstruct the super continent	Most evidence used to reconstruct the super continent	Some evidence used to reconstruct the super continent	Evidence not used to reconstruct the super continent
Explanation of evidence used to reconstruct super continent	Essay expertly explains evidence used to reconstruct super continent	Essay explains in an advanced manner evidence used to reconstruct the super continent	Essay explains in a basic manner evidence used to reconstruct the super continent.	Essay somewhat explains evidence used to reconstruct the super continent	Essay does not explain evidence used to reconstruct the super continent
Explanation of the theory of continental drift	Essay expertly explains the theory of continental drift	Essay explains in an advanced manner the theory of continental drift	Essay explains the theory of continental drift	Essay somewhat explains the theory of continental drift	Essay does not explain the theory of continental drift
Explanation of how RhSc is a model of Pangaea	Essay expertly explains how RhSc is a model of Pangaea	Essay explains in an advanced manner how RhSc is a model of Pangaea	Essay explains how RhSc is a model of Pangaea	Essay somewhat explains how RhSc is a model of Pangaea	Essay does not explain how RhSc is a model of Pangaea

HANDOUT 32 A Template for Rubric Construction

Attributes	5 Highly Proficient	4 Capable	3 Adequate	2 Limited	1 Inadequate	Weight

HANDOUT 33 Reflection Day 2 Afternoon

Name: _____ Date: _____

Describe a situation in which you used a performance assessment during your teaching. How does it compare to one designed using the GRASPS model?

HANDOUT 34 Moon Phase Unit Preconception Survey

Based on your discussion of the moon's location and appearance in the sky at noon today, predict what the moon will look like, and where the moon will be in the sky one week from now. Draw a diagram of your prediction indicating the date, the time, the horizon (face the south), and indicate the phase and position of the moon in the sky.

Write a one or two sentence explanation of what causes the phases of the moon. Supply a diagram that illustrates your answer.

HANDOUT 34A The WHERETO Model for Designing Stage 3

When selecting learning activities, visualizations, and assessments for Stage 3 of the Rock Cycle Unit, think about the following points:

W

How will you help students know *where* they are headed in this unit and *why* and what are the major assignments, performance tasks, and criteria by which the work will be judged)?

H

How will you *hook* students through engaging and thought-provoking experiences (e.g., issues, oddities, problems, and challenges) that point toward big ideas, essential questions, and performance tasks?

E

What events, real or simulated, can students *experience* to make the ideas and issues real? What learning activities will help students to *explore* the big ideas and essential questions? What instruction is needed to *equip* students for the final performances?

R

How will you cause students to *reflect* and *rethink* to dig deeper into the core ideas? How will you guide students in *rehearsing, revising,* and *refining* their work based on feedback and self-assessment?

E

How will students *exhibit* their understanding about their final performances and products? How will you guide them in self-*evaluation* to identify the strengths and weaknesses in their work and set future goals?

T

How will you *tailor* and differentiate instruction to accommodate your student's developmental needs, learning styles, prior knowledge, and interests?

O

How will you *organize* a sequence of learning experiences that will best develop and deepen student understanding, while minimizing likely misconceptions?

HANDOUT 35 Private Universe Viewing Guide

While you watch the video "Private Universe: A Study of Enduring Misunderstandings," keep these questions in mind:

1. What are the two major misconceptions discussed in this video?

2. What are two of the other misconceptions that Heather uses in her discussion of the two major ones?

3. What activities or visualizations might you use with Heather to help her overcome her misconceptions?

HANDOUT 36 Strategies to Reveal Misconceptions and Build Understanding

- Conduct a written Preconception Survey at the beginning of a unit
- Give students many opportunities to reveal their thinking and their emerging understandings.
- Create a classroom climate where it is OK to share one's misunderstandings and partial understandings.
- Positively reinforce students when they reveal their struggle to understand.
- Acknowledge to students that building understanding takes time.
- Encourage students to monitor their own understanding through self-checks, reflections, and ungraded quizzes.
- Use assessment techniques that make student thinking visible, such as drawing and concept mapping.
- Probe student responses to get at their deep, rather than, surface understandings.
- Make frequent checks for understanding to monitor student understanding.
- Use activities that force students to confront their misconceptions and rethink their understanding.

HANDOUT 37 Reflection Day 3 Morning

Name: _____ Date: _____

What insights have you had about the role of misconceptions in teaching and learning?

HANDOUT 38 Evaluating Visualizations

When evaluating the effectiveness of a visualization, consider both its basic design and your intended instructional use. Use these questions to guide your evaluation:

Grade level:

For what grade level is this visualization appropriate?

Instructional role:

What big and subsidiary ideas in Earth science will this visualization help students understand? Where does it fit in the WHERETO outline?

Accuracy:

Is this visualization scientifically accurate? Which person or agency created this visualization? What is the underlying data, and how was it collected and processed to create this visualization?

Background knowledge:

What content knowledge is needed to understand this visualization? Are preparatory activities or scaffolding needed to use this visualization effectively? If so, how can these be provided to students?

Embedded conventions:

What visual conventions does this visualization use that students might not understand or that might lead to confusion?

- *Scale:* Is the scale clearly indicated? Is there any exaggeration of scale? For example, is the vertical dimension exaggerated with respect to the horizontal dimension?
- *Legend and labels:* Are they present, clear, and adequate?
- *Projection:* Are there aspects of the projection (such as distortion of area) that need to be explained?
- *Color:* Is it clear what the colors in the visualization represent? Are the colors misleading or confusing?
- *Time and date:* Is the time and date information provided adequate to understand the visualization?

Misconceptions:

Might this visualization inadvertently introduce misconceptions or misunderstandings? If so, how can you provide additional information to guard against this misunderstanding?

HANDOUT 39 Evaluating Visualizations: An Example

An Example:

When evaluating the effectiveness of a visualization, consider both its basic design and your intended instructional use. Use these questions to guide your evaluation:

Visualization Evaluated: *Crustal Age of the World's Oceans* (found in the ESBD web site Teaching Resources/Visualizations by Design/Geosphere)

Grade level:

For what grade level is this visualization appropriate?

Grade 6, 7, or 8

Instructional role:

What big and subsidiary ideas in Earth science will this visualization help students understand? Where does it fit in the WHERETO outline?

Possible concepts this visualization may help uncover include:

- The age of the ocean floor varies from place to place.
- There are general patterns in the distribution of the age of the ocean floor.
- The distribution of the age of the ocean floor provides compelling evidence that plates move relative to one another.
- Plates move at varying rates and in varying directions.

It could be used as a (H) hook to engage students and then revisited again during the (E) explore, explain stage as well as to (R) review and reinforce.

Accuracy:

Is this visualization scientifically accurate? Which person or agency created this visualization? What is the underlying data, and how was it collected and processed to create this visualization?
It was produced by NOAA and appears to be scientifically accurate. The data comes from Scripps Institute of Oceanography.

Background knowledge:

What content knowledge is needed to understand this visualization? Are preparatory activities or scaffolding needed to use this visualization effectively? If so, how can these be provided to students?

The background content needed to understand this visualization depends upon what the user is expected to "read" from the image. At the introductory level, when used as a hook (H), users need to be able to distinguish landmasses from ocean floor. As they describe and discuss patterns, it would also be helpful to have general knowledge of the locations of continents and major oceans. At the more advanced level (E), if students are expected to gather evidence from the image to support the notion that plates move relative to one another, then they would need to have a prior understanding of plates and plate boundaries.

Embedded conventions:

What visual conventions does this visualization use that students might not understand or that might lead to confusion?

- *Scale:* Is the scale clearly indicated? Is there any exaggeration of scale? For example, is the vertical dimension exaggerated with respect to the horizontal dimension?

  There is no distance scale, but latitude and longitude lines are appropriately displayed.
- *Legend and labels:* Are they present, clear, and adequate?
  Students may need to be told that B.P. stands for before present.
- *Projection:* Are there aspects of the projection (such as distortion of area) that need to be explained?
  Not really. This particular projection does not appear to produce extreme distortions of the land masses.
- *Color:* Is it clear what the colors in the visualization represent? Are the colors misleading or confusing?
  The colors in the image are "false". The ocean floor does not look like this. Students might need help understanding that the colors represent age and not elevation.
- *Time and date:* Is the time and date information provided adequate to understand the visualization?
  Yes.

Misconceptions:

Might this visualization inadvertently introduce misconceptions or misunderstandings? If so, how can you provide additional information to guard against this misunderstanding?

Because the landmasses are gray and the ocean floor is vividly colored, the eye is often drawn first to the ocean floor. This makes it difficult for students to orient to the image. Call their attention specifically to the continental landmasses. Making sure students can locate North and South America, and perhaps Africa will help make the image less confusing.

HANDOUT 40 Visualization Sets

In this activity you will collaborate with your colleagues to evaluate the potential of using particular visualizations to address a set of understandings and Big Ideas in Earth science. Use the guidelines for evaluating visualizations to critically examine each of the visualizations in a set. Assume that you are interested in uncovering the Big Idea provided. The understandings that have been listed are all related to the Big Idea. However, each visualization will not necessarily target all of the understandings. As you discuss these visualizations, feel free to add or revise understandings as needed.

After you have evaluated the visualizations, be prepared to share:

- a visualization that your group would use for uncovering the Big Idea and in what part of WHERETO you would likely use it
- a visualization that your group would not use for uncovering the Big Idea
- the rationale for your selections (e.g. why you would or would not use them)
- issues or insights raised during your discussions

HANDOUT 41 Visualization Set 1: Geosphere

Big Idea:

Big Idea 5, The Geosphere
The movement of the Earth's lithospheric plates causes both slow changes in the Earth's surface (e.g., formation of mountains and ocean basins) and rapid ones (e.g., volcanic eruptions and earthquakes).

Understandings:

(You are encouraged to suggest additional understandings or revise the ones listed below.)

- The age of the ocean floor varies from place to place.
- There are general patterns in the distribution of the age of the ocean floor.
- New oceanic crust is formed where plates are pulling apart and that the presence of subduction zones means that oceanic crust does not get older than a few hundred million years.
- The dynamic motion of Earth's crust creates an ocean floor that varies in age in relation to its proximity to spreading ridges and subduction zones.
- The distribution of the age of the ocean floor provides compelling evidence that plates move relative to one another.
- As crustal plates move, their boundaries change so that new plates are created while others are recycled within the Earth.
- Convection currents in the mantle drive the motions of the plates.

Visualizations:

Refer to the Geosphere visualizations in the "Visualization Sets" section of Teaching Resources on the ESBD web site (www.esbd.org).

HANDOUT 42 Visualization Set 2: Hydrosphere

Big Idea:

Big Idea 12, The Hydrosphere
Circulation patterns in the oceans are driven by density differences and by exchange of momentum with the atmosphere.

Understandings:

(You are encouraged to suggest additional understandings or revise the ones listed below.)

- At the poles fresh water is frozen out of warm, salty seawater making it more saline and dense.
- More saline, dense water sinks to the ocean bottom.
- Surface water from low latitudes flows towards the poles to replace sinking cold water.
- Water in the world's deep ocean is circulated.

Visualizations:

Refer to the Hydrosphere visualizations in the "Visualization Sets" section of Teaching Resources on the ESBD web site (www.esbd.org).

HANDOUT 43 Visualization Set 3: Atmosphere

Big Idea:

Big Idea 10, The Atmosphere
The atmosphere exhibits long-term circulation patterns and short-term patterns known as weather—storms, hurricanes, and tornadoes.

Understandings:

(You are encouraged to suggest additional understandings or revise the ones listed below.)

- Atmospheric pressure is not the same everywhere on Earth.
- Like all fluids, air tends to flow away from regions of high pressure towards regions of low pressure. This flow of air is known as wind.
- Winds spiral around areas of low pressure; the motion is counterclockwise in the Northern hemisphere and clockwise in the Southern hemisphere.
- The direction and force of a wind depend on the size of the pressure difference, the distance between high and low pressure areas, and the Coriolis effect.
- As Earth rotates about its axis, moving bodies, like wind and water, appear to someone on Earth to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This phenomenon is known as the Coriolis effect.
- Some places on Earth are more likely to experience particular severe weather phenomena like tornadoes, hurricanes, thunderstorms, and floods while others are not.

Visualizations:

Refer to the Atmosphere visualizations in the "Visualization Sets" section of Teaching Resources on the ESBD web site (www.esbd.org).

HANDOUT 44 Visualization Set 4: Space Science

Big Idea:

Big Idea 20, Space Science
The relative positions and movements of the Earth, moon, and sun account for the seasons.

Understandings:

(You are encouraged to suggest additional understandings or revise the ones listed below.)

- Earth experiences seasons that change throughout the year.
- Seasons on Earth vary by location.
- Earth revolves around the sun.
- Earth's orbit, while elliptical, is nearly a perfect circle.
- Earth rotates on an axis that is tilted.
- Sunlight hits different latitudes at different angles at different times of year.

Visualizations:

Refer to the Space Science visualizations in the "Visualization Sets" section of Teaching Resources on the ESBD web site (www.esbd.org).

HANDOUT 45 Reflections Day 3 Afternoon

Name: _____ Date: _____

What insights have you gained about teaching with visualizations?

What is the main unanswered question that you leave the institute with today?

HANDOUT 46 Reflection Day 4 Morning

Name: _____ Date: _____

How did our work with visualizations yesterday influence your thinking as you searched for visualizations for your Stage 3 today?

What was your greatest challenge or struggle as you worked to apply WHERETO to your rock

HANDOUT 47 Reflection Day 4 Afternoon

Name: _____ Date: _____

Reflect on your experience in designing Stage 3 using the WHERETO model. How is this different from the way you have designed lessons and units in the past?

Please share any insights that you gained today about teaching and learning.

HANDOUT 48 Earth Science by Design Unit Construction Checklist

Stage 1 - Identify Desired Results

☐ Do the enduring understandings relate *directly* to the big ideas in Earth science?

☐ Are all of the essential questions "how" or "why" questions rather than factual "what" questions?

☐ Is each essential question linked *directly* to one of the enduring understandings?

☐ Is each item listed in "What Students will need to know and be able to do" a direct result of one of the essential questions?

☐ Do *all* of the essential questions lie at the heart of Earth science and reveal the richness and complexity of the topic?

Stage 2 - Determine Acceptable Evidence

☐ Does the unit performance assessment address *most* of the enduring understandings listed in Stage 1 instead of a subset?

☐ Does the performance assessment truly *convict* the student of understanding?

☐ Does the rubric adequately evaluate student *understanding*?

☐ Does the performance assessment allow the evaluation of the understanding of *each and every* student in a fair and accurate way?

☐ Does the performance assessment serve as a *motivator* for students to acquire the deep understanding the unit seeks?

☐ Does the unit performance assessment force students to employ the majority of the knowledge and skills students should be able to know or do in Stage 1?

☐ In addition to the performance assessment, does the unit include enough other assessments (quizzes, prompts or self-assessments) to reveal the degree to which students *have or have not* mastered the enduring understandings?

☐ Does the Preconception Survey reveal student misunderstandings?

Stage 3 - Plan Learning Experiences, Instruction, and Resources

☐ Does the collection of events in Stage 3 help to build *deep* and *enduring* understanding?

☐ Does each section of Stage 3 use a WHERETO letter, listing visualizations and Internet resources in sequence with the learning activities they augment?

☐ Does Stage 3 begin with an activity, demonstration, or discussion that addresses *why* students are studying the unit, and with one that uncovers *what* their preconceptions are?

☐ Does the unit have an engaging *hook* to grab students' interest?

☐ Does each student learning experience in the E section (explore/explain/equip/experiment) relate directly to the knowledge, skills, and abilities that underlie one of the essential questions?

☐ Does the unit provide the learning experiences that will help students excel on the performance assessment?

☐ Does each Web resource add perspective or deepen a student's understanding of the concept it relates to?

☐ Is each Web resource appropriate for the part of WHERETO in which it is used?

☐ Does the R (reflect/rethink) section, provide an activity or visualization that allows students to both review and look at a major concept in a different and engaging way?

☐ Does step E (evaluate) contain quizzes or self-assessments that allow students to monitor their own knowledge and proficiency as they progress through the unit?

☐ Are the activities tailored to your students' developmental needs, learning styles, prior knowledge, and interests?

☐ Does the unit *organize* student learning experiences, instruction, and resources using the WHERETO model?

Summative Questions

1. What are the strengths of this unit?

2. How could this unit be improved?

HANDOUT 49 Reflection Day 5 Morning

Name: _____ Date: _____

What insights about your unit and about the ESBD unit design process did you have as you reviewed your rock cycle unit using the *Unit Construction Checklist?*

HANDOUT 50 Reflection Day 5 Afternoon

Name: _____ Date: _____

Write the names of two other participants that you think you would work well with as a partner in ESBD. If you wish, briefly explain why.

What is the main understanding that you struggled with this week?

What unanswered question or questions do you have from this week's activities?

Please comment on the process we have followed this week, including such things as the general pace, the atmosphere, the small group configurations, the group work, the whole group discussions etc. We welcome any ideas you want to share about what is working well and what might need improvement. Use the other side of the sheet, if necessary.

HANDOUT 51 Unit Plan–Journey to Planet Earth

Author: Carla McAuliffe, TERC

Stage 1: Identify Desired Results

Unit Description

Journey to Planet Earth is an introductory unit that presents Earth science as a voyage of discovery aimed at understanding the planet on which we live. This unit introduces the Earth system, and the major features of Earth's surface through remote sensing. Students acquire modeling and mapping skills as well as begin to build understanding of the methods of scientific inquiry.

Some understandings in Earth science overarch units as year-long goals. Four overarching understandings that pertain to this unit are as follows:

- The Earth is a system.
- Scientific discoveries often arise from a shift in perspective.
- Technology has led to increases in scientific knowledge and contributes to both better and worse living conditions.
- Scientific inquiry is a complex, iterative, and ongoing process.

Relationship to the Big Ideas in Earth Science

Directly relates to Big Ideas 4, 21, and 24 while beginning to uncover Big Idea 1 and 22.

Big Ideas 1, 21, 22, and 24 would come up repeatedly in a year-long Earth science course. Even Big Idea 4 would grow in depth throughout the year.

1. Earth can be conceived as an interacting set of processes and structures composed of the atmosphere, geosphere, hydrosphere, and biosphere.

4. The surface of the Earth has identifiable major features—land masses (continents), oceans, rivers, lakes, mountains, canyons, and glaciers

21. Earth scientists use representations and models, such as contour maps and satellite images to help them understand the Earth.

22. Scientists use quantitative, qualitative, experimental and non-experimental methods of scientific inquiry to understand the Earth.

24. Technological advances, such as seismic sounding and satellite remote sensing, advance Earth science knowledge.

Unit Enduring Understandings:

1. Earth is a dynamic system of interacting structures and features.
2. Remote sensing offers a new lens through which to study and monitor planet Earth. When we view the Earth from above the surface, we see the ways in which humans and Earth processes have altered it.
3. Maps, images, and models, both 2-D and 3-D, are representations that depend upon scale, location, projection, time, knowledge, tools, technology, and perspective.
4. Scientific observations and questions deepen our understanding of planet Earth.

Unit Essential Questions

1. What evidence demonstrates that Earth is a system?
2. What do satellite data reveal about the Earth system?
3. How do images and maps as well as 2-D and 3-D models help us understand the Earth as a system?
4. What are *scientific* questions and observations?
5. What questions can we ask and what observations can we make about the Earth system?

Possible rewording for students:

- What *is* this place called *Planet Earth*? (Which of its features play a critical role in the *Planet Earth* system? How are natural processes and humans affecting it?)
- What can we find out when we look at *Planet Earth* from space?
- How can we get to know *Planet Earth* from a *scientific* perspective?
- What *scientific* questions do you have about *Planet Earth*?

What students will need to know and be able to do (knowledge and skills):

- Recognize that Earth is a system of interacting processes and structures that make up the atmosphere, geosphere, hydrosphere, and biosphere.
- Identify the major features of the Earth and their distribution such as land masses (continents), oceans, rivers, lakes, mountains, canyons, and glaciers.
- Describe that Earth is mostly water and that land is concentrated in the Northern Hemisphere.
- Picture map projections.
- Conceptualize scaled distances.
- Read and interpret a contour map.
- Recognize that a variety of satellites operate and that each specializes in collecting a specific type of data.

- Explain five applications of remote sensing to Earth science.
- Identify common features (i.e. roads, airports, rivers, irrigated fields, trees, etc.) visible in remote sensed images.
- Interpret remotely sensed images.
- Use Cartesian coordinates to locate features on a map or image.
- Use the data in a time-dependent process depicted in an image or series of images to predict future expected changes.
- Analyze images of changes occurring over time.
- Frame scientific questions and observations.

What do students typically misunderstand?

- Students frequently confuse latitude and longitude.
- Students may have difficulty conceptualizing scaled distances and areas.
- Students often get the notion that scientific inquiry takes place in discrete steps as in the "scientific method".
- Students may misunderstand the two-sided nature of technology.

Stage 2: Determine Acceptable Evidence

G What is the Goal of the performance?
Your goal is to plan and conduct a scientific research expedition to a feature of *Planet Earth.*

R What Role does the student assume in the performance?
You are an explorer from another world who wants to know more about *Planet Earth.*

A What Audience does the student address?
Your target audience is the voting public on your home planet.

S What is the Situation for the performance?
Your home planet has recently discovered

Planet Earth. Teams from your planet will be taking voyages of discovery to it. Before you depart on your journey, you will need to get to know *Planet Earth.* What are its major features and characteristics? Where are its natural resources located? In preparation for your trip, and as a way to help you navigate this strange new world, carefully study maps and images of *Planet Earth.*

Along with your team members, design an expedition to a feature of *Planet Earth* that you find exciting. Imagine that you have the technology that lets you journey anywhere — even to places of extreme temperature and pressure. How will you travel there? What supplies will you take?

When you arrive at your destination, create a "profile" of your feature using 2-D and 3-D models and representations. You may choose to model a significant event that happened at that place in the past. Conduct research to find out how your feature has changed over time. Describe how remote sensing helps you better understand this feature. Gather and interpret at least three different images or maps of this feature. How does this feature interact with another? What is the relationship of humans to this feature? What questions does this feature raise for you? What else would you like to know about it?

Because your home planet wants a complete understanding of *Planet Earth,* you will need to negotiate features with other teams so that each Earth system (e.g. geosphere, atmosphere, biosphere, hydrosphere) is represented.

Some features that you might choose to visit include the following: a volcano, a fault, an ocean current, the edge of two fronts coming together, the Mid-Atlantic ridge, a crater, a mountain range, or a large area of natural habitat, such as a rain forest or a desert.

P What Product should be produced?

You would like to take more expeditions to your feature in the future. To do this, you will need to convince funders on your planet that the processes taking place at your location are critical to the *Planet Earth* system and are in need of scientific study.

On your planet, everyone has the opportunity to vote for which of these types of projects should be funded. After returning from your journey, you will need to present your findings to the voting public at an open meeting where anyone is able to pose a question.

Make your presentation as exciting as possible. After all, you are unlikely to receive the votes of funders if you do not capture their attention and hold their interest. Be sure to present a compelling argument for the significance of your feature to the *Planet Earth* system.

Share your discovery with others by preparing:

- A written report
- An oral presentation with accompanying visual display (Your team might create a poster, overheads or graphics and animations on computer.)
- A model of your feature

S What are the Standards for the product?

The written report should contain:

- a description of the feature (i.e. size, shape, color, etc.)
- detailed information about your feature (i.e. location, age, history, etc.)
- its relationship to other features on *Planet Earth*
- its relationship to humans
- the significance of this feature to *Planet Earth*
- at least five questions for further research

The model may be:

- physical or computer-based

Your presentation to the voting public will consist of:

- a brief summary of the findings from your journey
- a compelling argument for the significance of this feature to *Planet Earth*
- your plans for future research
- an oral report accompanied by supporting visuals

The report, the model, and the presentation will:

- contain all requested information
- convey information clearly and in an organized manner
- engage the audience
- use graphics to illustrate ideas and support arguments
- be visually appealing

Preconception Survey

Quizzes, Tests, and Academic Prompts

Apollo 17 Pre/PostConception Quiz Planet Earth Discovery Quiz or Where in the World is....? Remote Sensing Quiz

Other Evidence

Stage 3: Plan Learning Experiences, Instruction, and Resources

Use WHERETO as a guide to describe the learning experiences, instructional strategies, and resources you will use to help students address the essential questions of the unit and achieve deep understanding of the big ideas.

W & H (Where are they headed and Hooks)

- On the first day of class, have students write observations about the Apollo image of Earth from space. Compare this to an end of year writing sample of the same image. Set up the situation for the first unit's performance assessment. Tell students, "Imagine you are an alien from another world and have recently discovered this planet. You are told that it is called *Planet Earth*. Use your knowledge of the processes taking place on the planet and your understanding of it as a system to write ten detailed observations of *Planet Earth* in this view from space." http://nssdc.gsfc.nasa.gov/image/planetary/earth/apollo17_earth.jpg
- Have a discussion about what students expect they might be learning about *Planet Earth* this year. Continue to reveal the scenario of the performance assessment. "Your goal is to plan and conduct a scientific research expedition to a feature of *Planet Earth*." (Refer to Stage 2 for details.) Then share the overall year-long and unit essential questions with students.

- Generate student excitement and discussion about the study of *Planet Earth* by showing the HoloGlobe Project Movie at: http://svs.gsfc.nasa.gov/vis/a000000/a000100/a000155/hologlobe_v3.mpg

E (Experience, Explore, Equip)

- Understanding the *Planet Earth* System

  Break students into "sphere" teams and have each one observe and analyze their sphere in the Hologlobe Movie at: http://svs.gsfc.nasa.gov/vis/a000000/a000100/a000155/hologlobe_v3.mpg

  Present the basic features of the Earth system, such as the information found at: http://www.cotf.edu/ete/ESS/ESSspheres.html and http://www.cotf.edu/ete/ESS/ESSmain.html

- Previous visits to *Planet Earth*

  Tell the class that early explorers from their planet visited *Planet Earth* in the past. Share what they saw and learned. (Use this context as an opportunity to incorporate historical information into the scenario about *Planet Earth*, including geologic history and technological discoveries.)

- Flattening *Planet Earth*

  Have students peel apart paper models of *Planet Earth* and flatten them to demonstrate how map projections distort Planet Earth's surface. Build the models shown here ahead of time: http://www.earthkam.ucsd.edu/public/educators/pdf/GeoMapsTennisBallGlobe.pdf

- Interpreting Remotely Sensed Images

  After completing the activities in *Watching Over Our Planet from Space* at http://www.ccrs.nrcan.gc.ca/ccrs/learn/tutorials/youthkit/intro_e.html students

  – will be familiar with the basic concepts of "remote sensing" technology;

  – will be able to recognize/interpret some features in satellite images;

  – will be able to describe how remote sensing contributes to monitoring the environment.

  For reference, refer them to the Fundamentals of Remote Sensing tutorial at: http://www.ccrs.nrcan.gc.ca/ccrs/learn/tutorials/fundam/chapter1/chapter1_1_e.html

  Introduce NASA's Earth Science Enterprise at: http://earthobservatory.nasa.gov/Library/ESE/ and describe the Earth Observing System.
  Conduct *Satellite Search*

  Conduct *Case Study: New Land along the Pearl River in Southern China* at http://serc.carleton.edu/eet/measure_sat/case_study.html

- Reading and Interpreting Contour Maps

  Refer students to the online tutorials *Visualizing Topography* at: http://reynolds.asu.edu/topo_gallery/intro_title.htm

  How are Landforms Represented on Flat Maps? at: http://earthsci.terc.edu/content/investigations/es0307/es0307page01.cfm?chapter_no=investigation
- What are *Scientific* Questions?

  Hold a class brainstorming of questions, followed by discussion.
- Locating Images of *Planet Earth*

  Refer students to the following sites:
  NASA's Earth Observatory
  http://earthobservatory.nasa.gov
  The Gateway to Astronaut Photography of the Earth
  http://eol.jsc.nasa.gov/
  ISS EarthKAM
  http://www.earthkam.ucsd.edu/
  Exploring Earth from Space Lithograph Set
  http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Exploring.Earth.From.Space/

R (Reflect, Rethink)

- Have students write a reflective essay on one of the stories at *Earthshots:Satellite Images of Environmental Change* http://edc.usgs.gov/earthshots/slow/tableofcontents
- Review with *How are Earth's Sphere's Interacting?* at http://earthsci.terc.edu/content/investigations/es0103/es0103page01.cfm?chapter_no=investigation

E (Exhibit)

- Facilitate student presentations on their findings about *Planet Earth*. Direct the class to assume the role of the voting public on the home planet.

HANDOUT 52 Satellite Search Sites

Satellite/Sensor

- TOPEX/Poseidon
  http://topex-www.jpl.nasa.gov/index.html
- Landsat 7/ETM+ (Enhanced Thematic Mapper plus)
  http://landsat.gsfc.nasa.gov/
- TRMM (Tropical Rainfall Measuring Mission)/Microwave Imager
  http://trmm.gsfc.nasa.gov/
- QuickSCAT/SeaWinds Scatterometer
  http://windss.jpl.nasa.gov/missions/quikscat/quikindex.html
- SeaStar/SeaWiFS
  http://seawifs.gsfc.nasa.gov/SEAWIFS.html
- Terra/ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)
  http://asterweb.jpl.nasa.gov

For a current list of relevant web sites, refer to the "Satellite Search" section of Teaching Resources on www.esbd.org.

HANDOUT 53 Satellite Search Question Sheet

In this activity, you will describe the major characteristics of one Earth observing satellite instrument and the kind of data it collects. Your group will showcase the Internet site for this instrument, highlighting the visualizations and teaching resources hosted on this site.

Satellite Name:_____

Instrument Name: _____

How does the instrument gather data?

What kind of data does this instrument collect?

What are some applications of the satellite data? How do Earth scientists use them?

Where on the web site are the satellite data located?

What other resources does this site offer for teachers and students?

HANDOUT 54 Reflection Day 6 Morning

Name: _____ Date: _____

What insights have you gained about satellite data? Which type(s) of data are you most likely to use in your teaching?

HANDOUT 55 Reflection Day 6 Afternoon

Name: _____ Date: _____

As you begin to plan your unit, what stage do you feel the most comfortable with? What stage do you feel the least comfortable with? Explain your feelings.

What was your greatest struggle as you worked on Stage 1 of your unit today?

HANDOUT 56 Video Discussion Questions: Part 1

Reports From the Field video (about 9 minutes)

What did Sam and Anne indicate were the major changes in their classroom practice as a result of ESBD?

How did their students experience the new approach?

What new demands did ESBD make on students?

HANDOUT 57 Reflection Day 7 Morning

Name: _____ Date: _____

What insights did you gain from the video and discussion about the challenges of implementing ESBD?

HANDOUT 58 Reflection Day 7 Afternoon

Name: _____ Date: _____

Share something that you feel particularly good about in your unit design.

Comment on the process of using the Unit Checklist with your partner to evaluate Stage 1 of your unit. What did this review process help you see about your unit that you might not otherwise have noticed?

HANDOUT 59 Video Discussion Questions: Part 2

Challenges of Stage 2: Assessment (about 9 minutes)

How does Sam use information about student misconceptions differently now?

What does Anne say about how she deals differently with assessment?

What do they say about how ESBD affects different kinds of students?

HANDOUT 60 Reflection Day 8 Morning

Name: _____ Date: _____

Please share any insights about ESBD and assessment that you gained from the video.

HANDOUT 61 Reflection Day 8 Afternoon

Name: _____ Date: _____

What was your greatest struggle as you worked on your unit today?

HANDOUT 62 Video Discussion Questions: Part 3

Challenges of Stage 3: Learning Activities

What do Anne and Sam identify as the challenges of implementing the ESBD approach?

How did Anne cope with some of the anxieties of implementing the new approach?

HANDOUT 63 Reflection Day 9 Morning

Name: _____ Date: _____

Please share any thoughts about the video that you felt were particularly helpful. Be as specific as possible.

HANDOUT 64 Reflection Day 9 Afternoon

Name: _____ Date: _____

How has the institute experience influenced your thinking about the scientific content that you teach?

HANDOUT 65 Reflection Day 10 Morning

Name: _____ Date: _____

If a colleague asked you how attending the ESBD Institute influenced the way you think about lesson planning and student learning, what would you tell them?

HANDOUT 66 Reflection Day 10 Afternoon

Name: _____ Date: _____

What enduring understanding do you leave the institute with?

HANDOUT 1 Discussion Questions for Chapter 2 of How People Learn: Bridging Research and Practice

At the Fall Conference, you will discuss one of these questions in a small group with your colleagues. Come to the conference prepared to discuss each of the questions.

1. What is metacognition? What role does it have in teaching and learning, i.e. why is it important? How does an ESBD approach to instructional design use metacognition to achieve deep and enduring understanding?

2. The chapter makes a distinction between the expert and the novice. How does an expert differ from a novice? What can we learn from the novice-expert distinction that will help us design instruction that helps students achieve deep and enduring understanding?

3. The authors of the chapter write that effective learning environments should be:

    - Knowledge-centered
    - Learner-centered
    - Assessment-centered and
    - Community-centered

How does the ESBD approach to teaching and learning incorporate these recommendations?

HANDOUT 2 Preconception Survey Checklist

1. Are the survey questions aligned with the unit's enduring understandings and essential questions?

2. Does the survey get at most of the unit's big ideas or at least tap those that students might have preexisting knowledge about?

3. Does the survey take account of what students typically misunderstand?

4. How well does the survey help to reveal student thinking and understanding?

5. Are the results of the survey likely to help the teacher plan the teaching of the unit?

6. Is the survey "student friendly?"

HANDOUT 3 Scientific Revolution: The Development of the Theory of Plate Tectonics: An ESBD Unit (edited)

Unit Enduring Understandings:

The theory of plate tectonics was once a new idea; it is now widely accepted by most scientists because of the evidence that has been collected which supports it.

The earth's crust is made up of plates.

Continents are part of the earth's plates; when the plates move the continents also move.

Over millions of years the continuous movement of the Earth causes the continents (landmasses) to merge and divide repeatedly.

Unit Essential Questions:

How did the theory of plate tectonics evolve?

What is the mechanism that drives the movement of the continents? What is its fuel?

What allows the continents to move?

What evidence supports the theory of plate tectonics?

Why did competent scientists reject the idea of continental drift?

Why is this theory a revolution?

What do students typically misunderstand?

Students often think that:

Science is static.

Scientific data has only one interpretation.

Scientific theories are based on evidence that can be observed or measured directly.

Continents do not move.

Continental movement cannot be measured because it is so slow.

The continents are floating on the oceans and not attached to the crust.

The ocean floor is flat.

Earthquakes happen randomly.

The continents are plates.

The oceanic crust does not move.

Scientists have always believed that the plates move.

Scientists have always believed that sea floor spreading causes the plates to move.

Preconception Survey:

If you were looking down on the Earth from space 200 million years ago, what would it look like?

Draw what you think the ocean floor would look like if you could walk between North America and Europe.

Describe what is under the continents.

Describe what happens to the ocean floor when the continents move during continental drift.

What allows the continents to move?

Where does the energy needed to move the continents come from? Explain how this energy moves the continents.

HANDOUT 4 Earthquakes and Volcanoes: An ESBD Unit (edited)

Unit Enduring Understandings:

Volcanoes and earthquakes indicate the high temperatures and pressures that exist in earth's interior.

Studying historical earthquakes and volcanic eruptions improves our understanding of earth's processes.

Volcanism and seismic activity vary across the globe.

Although it is known where earthquakes and volcanic eruptions are likely to happen, there is currently no reliable way to predict precisely when an event will occur.

Unit Essential Questions:

What do earthquakes and volcanoes tell us about what is happening inside the earth and on the surface?

Can we predict earthquakes? Can we predict when volcanoes will erupt?

Do you have to worry about a volcanic eruption or earthquake where you live? Why or why not?

What do students typically misunderstand?

Students often think that:

Earthquakes occur when whole plates slide past each other.

Earthquakes create a gap or hole in the earth's surface.

Earthquakes occur at one depth.

Lava that erupts out of a volcano originates from earth's core.

Earthquakes cause volcanic eruptions.

Plate boundaries are the same as faults.

Lava comes out of all volcanic eruptions.

Preconception Survey:

Why do you think there are or are not earthquakes in Massachusetts?

What causes earthquakes?

Why do you think there are or are not volcanoes in Massachusetts?

What causes volcanoes?

Can we predict when an earthquake will happen?

Can we predict when a volcano will erupt?

Where do earthquakes happen in the earth?

Where does lava come from?

HANDOUT 5 Global Warming: What is It and What Can We do About It? An ESBD Unit (edited)

Unit Enduring Understandings:

There is a delicate balance between the energy of the sun and the atmosphere. This balance allows the Earth to maintain a temperature at which life as we know it can thrive.

The actions of human beings, both deliberate and unintentional, are changing the atmosphere. This affects the future of the Earth.

The ability of human beings to collect data and to decode the Earth's atmospheric patterns grows daily through use of sophisticated technology. Scientists are constantly making new discoveries and theories.

Unit Essential Questions:

How big is the atmosphere? How strong is it?

What takes care of what? Does the atmosphere take care of humans? Do humans take care of it? Can the atmosphere take care of itself?

The atmosphere has changed over time. What does its future hold?

What do students typically misunderstand?

Students often think that:

- The greenhouse effect is bad.
- The greenhouse effect is created by human beings.
- Global warming has to do with daily weather rather than long-term climate.
- There is no support for the idea of global warming.
- There is nothing that can be done about global warming.
- The ozone hole is responsible for global warming.
- The atmosphere goes on forever, or, it does not exist.

Preconception Survey:

1. If you could fly and you went straight up, what do you think you would find? What would happen to your body? Could you breathe? Would you get hot or cold? How far would you get before things started happening?
2. How do you think our planet Earth will change in your lifetime? In your children's lifetime? Will the temperature or weather change? How?
3. What have you heard or what do you think you know about global warming?

HANDOUT 6 Daily Weather: An ESBD Unit (edited)

Unit Enduring Understandings:

Weather changes constantly with changes in air temperature, moisture content, and air pressure.

The importance of weather in our daily lives has led us to develop technology to constantly collect data and track weather systems around the globe.

Movement of and interactions between air masses result in changes in the weather.

Clouds provide information about what is taking place in the atmosphere.

Unit Essential Questions:

Why is weather so important to us?

How do temperature and pressure affect the movement of air?

How do differences in water vapor content, pressure, and temperature result in changes in weather?

What relationships exist between the weather and types of clouds?

What do students typically misunderstand?

Students often think that:

All clouds are the same.

Predicting weather should be easy.

Clouds and fog are not the same.

Air is uniform in temperature, pressure, and water vapor.

Changes in air temperature are gradual.

Any condensation in the atmosphere results in precipitation.

Preconception Survey:

How does weather affect our daily activities?

The weather is on TV, radio, etc. many times a day. Where does the information about weather come from?

What causes the weather to change?

What causes changes in temperature, not over the course of a year, but over the course of a week?

How do clouds form and what can they tell us about the weather?

HANDOUT 7 Reviewing The Six Facets of Understanding - Definitions from Understanding by Design

Explanation

Sophisticated and apt understandings and theories, which provide knowledgeable and justified accounts of events, actions, and ideas.

Interpretation

Narratives and translations that provide meaning.

Application

The ability to use knowledge effectively in new situations and diverse contexts.

Perspective

Critical and insightful points of view.

Empathy

The ability to identify with another person's feelings or worldviews.

Self-Knowledge

The wisdom to know one's ignorance and how one's patterns of thought and action inform as well as prejudice understanding.

HANDOUT 8 Perspective and ESBD

1. Each of these quotes from Dr. Art's book provides understanding through the facet of perspective. Pick one or more of these quotes and refer to the book as necessary to help you discuss how the quote uncovers a deep understanding about the Earth system. (20 minutes)

> "The water that we drink connects us ultimately with the living beings that inhabited the planet before us, that inhabit Earth today and that will inhabit it in the future." Pg. 33
>
> " . . . the different reservoirs of the water cycle can differ greatly in the amount of water they contain. They also differ in the rate at which it enters and leaves. . . a water molecule stays in the ocean about 3,000 years, while it stays in the atmosphere only 9 days. The same water cycles over and over through the various reservoirs." Pg. 30
>
> "Earth has dry land because the processes that build mountains balance the erosion processes. In the course of just 18 million years, the continents would be reduced to sea level and oceans would cover the Earth." Pg. 24
>
> "Compared to the geosphere and hydrosphere, the atmosphere is the most sensitive and changeable of Earth's 'spheres'. It can change quickly because it is comparatively very small. In terms of mass, the whole Earth system contains a million times more solid stuff than gas. Therefore, if a small part of Earth's solid stuff changes to gas and enters the air, it can have a major effect on the atmosphere." Pg. 34
>
> "The global carbon cycle is currently not in balance. . . Approximately 6 billion tons of carbon in the form of carbon dioxide enters the atmosphere due to the burning of fossil fuels for transportation, heating, cooking, electricity, and manufacturing." Pg. 41
>
> "From a systems point of view, Earth is essentially a closed system with respect to matter." Pg 11
>
> "From a systems point of view, Earth is essentially an open system with respect to energy." Pg 13

2. Discuss how you might incorporate the facet of perspective into your Earth science teaching. (20 minutes)

HANDOUT 9 ESBD Fall Conference Unit Checklist

Assessing the Unit Components:

☐ Is the list of *Essential Questions* aligned with the *Enduring Understandings*?

☐ Are the tasks listed in *What Students Will Need to Know and Be Able to Do* aligned with the *Essential Questions?*

☐ Has the *Preconception Quiz* been written in the space provided in Stage 2?

☐ Does the Stage 2 performance assessment measure student understanding of the majority of the enduring understandings of the unit? Could students do well on the assessment with out completing the unit (false positive)?

☐ Has the rubric for the Stage 2 performance assessment been completed?

☐ Are there any visualizations or other Internet resources listed in Stage 3 that are unconnected with an activity or demonstration?

☐ Have an adequate number of visualizations been used in Stage 3 activities?

☐ Have the Pre- and Post-conception Quizzes been listed in the W and last E phase respectively?

☐ Has an effective activity or self-assessment quiz been used in the Reflection section of Stage 3?

☐ Check the alignment of all components since elimination of an essential question often means other elements of the unit should be omitted.

Assessing Overall Structure and Implementation:

☐ How does this unit fit with the other units taught this year?

☐ What is the schedule for teaching this unit? Is there sufficient or too much material for this time frame?

☐ How are students going to be made aware of the goals of the units (posting essential questions, etc.)?

☐ Are there issues regarding needed materials? If so, can substitutions be made?

Questions or Issues to Discuss with Mentor

HANDOUT 10 Visualization Sharing Guidelines

You will briefly demonstrate and discuss one visualization from your ESBD unit. Follow these steps in your three to five minute presentation.

1. Demonstrate how the visualization works (how one uses it).

2. Explain how you are planning to use the visualization in your unit (as a hook, reflection, review, etc.). What enduring understanding does it target?

3. Explain how it promotes deep and enduring understanding through a facet of understanding.

HANDOUT 11 Reflection Day One

Name:_____Date:_____

What new insights have you had about how to help students achieve deep and enduring understandings in Earth science?

What new ideas or strategies that came up today might you want to incorporate into your teaching?

HANDOUT 12 Summary Sheet for "Aiming for Deep and Enduring Understanding" Activity

Unit Enduring Understanding	Facet of Understanding	Brief Description of Activity
	Explanation	
	Interpretation	
	Application	
	Perspective	
	Empathy	
	Self-Knowledge	

HANDOUT 13 Example Activities for the Six Facets of Understanding

Facet	Sample Activity
Explanation	Students use a light bulb (the sun) and an orange (the moon) to give an explanation of how the moon phases are formed from the perspective of the Earth (their head).
Interpretation	Students research historical explanations of the phases of the Moon (e.g. Aristotle, Plutarch, cultural stories, etc.)
Application	Students are given Galileo's original 1612 drawing of the phases of Venus. Using a light bulb and an orange, students verify these observations and document the relative positions of the sun, Venus, and Earth that produce these phases.
Perspective	Students are shown a picture of the Earth from the moon when the Earth is in a waning gibbous phase and then they discuss the relationship of the sun-Earth-moon positions that account for Earth's appearance.
Empathy	Students consider the following scenario: A visitor from another planet, a female alien named Myrna, visited your school last weekend. Myrna's planet has no moons orbiting it. Put yourself in Myrna's place. What might it be like to live on a planet without a moon? How might life on Earth be different without a moon?
Self-Knowledge	Students in small groups compare their postconception quiz with their preconception quiz and discuss how their answers changed.

HANDOUT 14 Volcanic Eruptions Rubric Construction

Attributes	Levels of Performance 1	2	3	4	Weight
Geologic story	Incomplete or inaccurate geology content	Somewhat accurate geology content	Mostly accurate content	Geology content accurate and complete	
Eruption prediction supported by evidence	No evidence or misapplied evidence	Some evidence supports prediction	Most evidence supports prediction	All evidence clearly supports prediction	
Maps and visuals that support the presentation	Maps and visuals used decoratively	Maps and visuals somewhat support the presentation	Maps and visuals mostly support the presentation	All maps and visuals appropriately support presentation	
Emergency response based on prediction	Response is not based on prediction	Response somewhat based on	Response mostly based on prediction	Response based prediction completely on prediction	
Communication	Presentation is difficult to follow and is incomplete of Pangaea	Presentation is difficult to follow but is complete	Presentation is well structured, well articulated, but incomplete	Presentation is well structured, well articulated, and complete	

HANDOUT 15 Journaling for Self-Reflection

You have been asked to keep a journal of how your ESBD unit unfolds as you teach it. Writing down thoughts often helps to shape and clarify them. Keeping a journal of your teaching can encourage self-reflection, as well as provide a record of events as they occur. Try to capture your insights as best you can. Your journal is your own "thinking space."

Journaling for description can be very useful, but potentially time consuming. Getting lost in the details can feel overwhelming and is one reason many teachers give up journaling. Provide the level of detail that you need to enable you to analyze and reflect on the teaching and learning process. More important than tracking events, is using a journal to track your thinking.

You may find it useful to organize your journal in a particular format or you may simply wish to write your thoughts in a freeform manner. Use sketches or graphic organizers if you like. Consider incorporating three aspects into your entries: 1) description, 2) analysis, and 3) reflection. The questions below are intended to guide, but not limit your journaling efforts.

Describe:

What happened during the lesson? What were you doing? What were the students doing? What do you remember most?

Analyze:

What worked? What didn't work? What evidence do you have that students either understood or misunderstood?

Reflect:

What does it mean? What ideas do you have about what you might do differently in the future? What insights do you have you about teaching and learning?

HANDOUT 16 Reflection Day Two

Name:_____Date:_____

Do you feel prepared to implement your ESBD unit? Why or why not?

What part of the conference was the most useful to you?

Is there a topic that was not included in the conference that you would like to have seen addressed?

HANDOUT 17 Earth Science by Design Classroom Observation Guide

This guide is intended to structure the classroom observations that partners make of each other.

The purpose of the classroom observation is to provide feedback to your partner and to the Earth Science by Design project staff about what actually happened in the session. We believe that this feedback can help teachers improve their teaching. It also helps the project staff know how these sessions embody the principles of Understanding by Design.

The guide is organized in terms of questions about actual behavior. You should focus on directly observable behavior and should not include opinions or interpretations of the behavior. Please try to be objective!

Whenever possible, provide specific examples of the behavior you observed. Include as much detail as you can. (i.e. "Teacher asked for thumbs up/down signal three times and distributed a short written quiz at the end of the lesson.")

No one class session will include all the behaviors described below, so some questions will remained unanswered, or will simply be answered "no" or "not applicable."

Date _____Approx. # of students in class_____

Teacher name_____

Observer name _____

Unit name _____

This session is # _____ of _____ sessions anticipated in this unit.

(Please attach any handouts students used in this session.)

Briefly describe the overall structure of this session:

The opening or introduction of the session:

The main activities of the session:

The closing or wrap-up of the session:

Describe Specific Teacher Behaviors Observed During this Session

Did the teacher introduce or review the essential questions of the unit? Describe.

Did the teacher make clear to the students how the activities of this session are related to the essential questions and the unit goals? Describe.

Did the teacher keep this session "on track" and aligned with unit goals, i.e. avoided "side trips" and tangential activities/discussions? Please describe.

Did the teacher use informal methods to check for student understanding during the session? Please describe.

Did the teacher relate today's learning experiences to the culminating performance assessment? If so, please describe.

Did the teacher review or reinforce the expectations for the performance assessment?

Did the session include learning experiences that build the knowledge and skills that help students explore essential questions and big ideas? If so, describe the activities.

Did the teacher elicit student preconceptions or misconceptions and then use this information to guide the work of the session? If so, describe.

During this session, did students and/or the teacher use Web resources? Please describe.

Student Behaviors During this Session

Did students discuss or refer to the essential questions of the unit? If so, please describe.

Did students discuss or refer to the performance assessment? If so, please describe.

Did students relate today's learning experiences to the big ideas? If so, please describe.

Did students seem to be attentive and engaged in the lesson? Describe.

Did students ask questions or make statements that go beyond fact gathering and that reflect conceptual struggles? If so, please describe.

Did students demonstrate their understanding (i.e. "I get it! Now I know what you mean by the rock cycle, etc.")? If so, please describe.

In this session, were students asked to reflect upon and review essential questions? If so, how was this structured?

Were the students encouraged to monitor their own progress and learning? If so, please describe.

Reflections on the Session by the Partners

After this session, discuss your observations of this session with your partner. Encourage your partner to interpret and reflect upon their actions. Use this space to record your joint reflections about the session.

Reflection questions:

1. Did the session fulfill the goals the teacher had for it?

2. How could the session have been improved?

HANDOUT 18 Earth Science by Design Classroom Observation Guide – Instructions for Partners

The classroom observation guide is intended to structure the classroom observations that partners make of each other. The purpose of the classroom observation is to provide feedback to your partner and to the Earth Science by Design project staff about what actually happened in the session. We believe that this feedback can help teachers improve their teaching. It also helps the project staff know how these sessions embody the principles of Understanding by Design.

The guide is organized in terms of questions about actual behavior. The observer should focus on directly observable behavior and should not include opinions or interpretations of the behavior. Please try to be objective!

Whenever possible, provide specific examples of behavior you observed. Include as much detail as you can. (i.e. "Teacher asked for thumbs up/down signal three times and distributed a short written quiz at the end of the lesson.") No one class session will include all the behaviors described below, so some questions will remained unanswered, or will simply be answered "no" or "not applicable."

We recommend that you read over the guide to familiarize yourself with the questions before doing the observation but that you do not use the guide itself during the observation. Instead, focus on what is happening, and take "running notes" of the session as it unfolds. The questions in the guide will help you know what to focus on. For example, watch for the teacher's use of "informal checks for understanding," listen for discussion of the essential questions and references to the performance assessment, and observe student behavior. Use your "running notes" to fill out the guide afterwards.

After the session, schedule a time to sit down with your partner and discuss the session. (It would be ideal if there is a teacher planning period you could use for this purpose.) Go over the notes and the guide to make sure you both agree on what was observed. Use the reflective questions to help write up your reflections on the session.

Make 2 copies of the observation guide and of any handouts used by students during this session. Keep one copy for yourself and give one copy to your partner.

HANDOUT 19 Earth Science by Design - Example of "Running Notes" of a Classroom Session

Here is an example of the kinds of notes you might take in a classroom. From these notes you can then fill out the *Classroom Observation Guide*.

The Context of this Class Session (from prior discussion with the teacher and from reviewing the unit planner)

This class session is part of an introductory unit, *Journey to Planet Earth*. The unit presents Earth science as a voyage of discovery aimed at understanding the planet on which we live. It introduces the Earth system, and the major features of Earth's surface through remote sensing. Students acquire modeling and mapping skills as well as begin to build understanding of the methods of scientific inquiry.

A View from the Classroom

A remote sensed image of Buenos Aires is displayed onscreen to students as class begins.

The following questions and directions are posted, "Where on Earth do you think this image is from? What do you think the image shows? Write down your thoughts on a paper and discuss them with your team." Mrs. X takes a minute to take roll and organize paperwork.

Mrs. X points to the image. "Raise your hands and indicate with your thumb how confident you feel about what you wrote. OK. We will return to this image at the end of class."

"Remember that one of the BIG goals in this course is to use images of Earth from space to help us better understand our planet. We want to think of images as data that we can analyze and interpret, just like we do a table or a graph."

"Let's take a look at our essential questions for this unit." *Mrs. X. points to the bulletin board.* "Today we will focus on the second one,

How do images, maps, and models help us understand the Earth system?"

"As we continue on our journey to Planet Earth, let's examine some remote sensed images of Earth. Today, we will learn to recognize common features, such as roads, rivers, trees, irrigated fields, airports, and the like, as seen from the air. We will also ask questions about why things are where they are. Why is an airport located in one area and not another?" *While talking, Mrs. X is advancing frames of a slide show depicting ground-based views of these features.* "When your team plans its expedition to your chosen volcano, fault or other unique place, you will need to gather and interpret at least three images or maps. You will need to ask questions about what you see. What we learn today will help you with that part of your final project. Even if your team is planning a trip to the bottom of the ocean, as part of the voting public, you will need to be able to recognize the features we study today when you listen to the presentations from other teams. This will enable you to make an informed decision about whose proposed project should receive funds for further research."

"Think about what you learned about remote sensing yesterday. Remember that a variety of satellites operate and that each specializes in collecting a specific type of data. Recall and write down one type of information that we collect from these satellites."

Mrs. X then calls on various students.

i.e. "Sarah, would you please share what you wrote? "

Students respond with, "sea surface temperature, movement of storm systems, land temperature, etc." When a student response was incomplete she asked, "Would you explain what you mean?" When he was still unsure, she asked if he needed help and then called upon another student to help him.

"In addition to satellites, space shuttles and planes fly over Earth and take pictures. Today, we will explore some of these more detailed, small-scale images."

Mrs. X. stops talking and distributes papers to the groups. "This is a table of image features." *Mrs. X holds up the table and points to it.* "Here is a reference set of images." *Mrs. X holds up two of the images from the reference set.* "It is your goal to make sure that you and your teammates can identify these features in any remote sensed image. As you work through the questions, *(Mrs. X. holds up the question sheet)* make sure all of your team members are in agreement. There are two parts to the activity. One part uses the printed image set at your desks. The other part uses the computer stations. The class will be split in half. You will have 10 minutes for each part. Teams 1 to 4 will start at the computers. Teams 5 to 8 will remain at the desks. In ten minutes we will switch. After that, you will have 10 minutes to quiz each other on image features." *Mrs. X. has eight groups of four students in this class. She has four computer stations and uses a split class structure. Half of the teams work with the printed images. The other half works at the computer. They switch places after 10 minutes.*

Mrs. X. circulates among the teams as they work through the activity, Finding Features.

Students discussed their responses to the question sheet items. In particular, students are overheard discussing these two questions:

Write down something your team cannot identify on at least one of the images.

Write three questions raised by the image.

Activity: Quiz your teammates. Many students turn this activity into a game, pretending they are contestants and game show hosts.

Mrs. X flips the light switch three times. "OK. May I have everyone's attention? Tomorrow we will share and discuss the questions that today's images raised for your team. We will consider how these images show evidence of Earth's systems." *Mrs. X points to the image of Buenos Aires, now displayed again at the front of the room.* "For now, I'd like for us to return to the image with which we started. Take a minute

and look over what you wrote at the beginning of class. Go ahead and make any changes you'd like or add to what you wrote." *Mrs. X. pauses for a couple minutes, checking to see if students are finished writing.*

"Now, raise your hands and indicate with your thumb how confident you feel about what you have now written. "

Mrs. X points to features and asks for volunteers to identify them. After discussing features she asks if anyone thinks they know where on Earth this image is located. Since no one correctly identifies where the image is from, Mrs. X. informs the students of the location of the image. She puts it into a larger geographic context by having students open their texts and find Buenos Aires on a world map.

"What do you wonder about when you look at this image? Think of at least one "I wonder…" statement that this image brings to mind. Share this and any others with your teammates. "

Student responses include, "I wonder what the climate is like for the people who live there and I wonder where the river sediments come from." Noticeably absent are statements like, "I wonder why we have to know this?"

"Recorders, please hand in a list of at least four statements for the team, along with the question sheet for the activity. " Materials specialists from Teams 2 & 6, please collect all the papers." *Recorders hold up a stack of paper for the two team specialists that move from group to group collecting papers. These two students then hand the papers to Mrs. X.*

HANDOUT 20 Earth Science by Design Classroom Observation Guide: Completed Sample

This guide is intended to structure the classroom observations that partners make of each other.

The purpose of the classroom observation is to provide feedback to your partner and to the Earth Science by Design project staff about what actually happened in the session. We believe that this feedback can help teachers improve their teaching. It also helps the project staff know how these sessions embody the principles of Understanding by Design.

The guide is organized in terms of questions about actual behavior. You should focus on directly observable behavior and should not include opinions or interpretations of the behavior. Please try to be objective!

Whenever possible, provide specific examples of the behavior you observed. Include as much detail as you can. (i.e. "Teacher asked for thumbs up/down signal three times and distributed a short written quiz at the end of the lesson.")

No one class session will include all the behaviors described below, so some questions will remained unanswered, or will simply be answered "no" or "not applicable."

Date Approx. September 20, 2006 Approx. # of students in class 25

Teacher name Mrs. X.

School name School Circle Middle School

Observer name Observer Y.

Unit name Journey to Planet Earth

This session is # 5 of 16 sessions anticipated in this unit.

(Please attach any handouts students used in this session.)

Briefly describe the overall structure of this session:

The opening or introduction of the session:

At the beginning of class, Mrs. X displays an image of Buenos Aires, along with questions for students to answer. The following text is posted, ""Where on Earth do you think this image is from? What do you think the image shows? Write down your thoughts on a paper and discuss them with your team." She reminds students of an overarching understanding and an essential unit question that will be the focus of today's session. Mrs. X. tells students that today they will learn to recognize features in remote sensed images as well as ask questions about them. Mrs. X informs students how today's session relates to the final project. She helps them to recall the key concept of the previous session.

The main activities of the session:

Students are given a reference set of images with key features identified. Students examine printed images and a selected set of images on the Internet. They share and discuss ideas with team members as they complete a question sheet. The question sheet probes not only their ability to recognize features but also guides them to analyze images for geographic clues and evidence of Earth's systems. Students quiz each other on image features.

The closing or wrap-up of the session:

At the end of class, students return to the Buenos Aires image and identify features in the image. Mrs. X informs the students of the location of the image and puts it into a larger geographic context with a map presentation. Students write, "I wonder…" statements, share them with teammates, and turn them into Mrs. X, along with the question sheets from their activities.

Describe Specific Teacher Behaviors Observed During this Session

Did the teacher introduce or review the essential questions of the unit? Describe.

Yes. Mrs. X. both stated the question and pointed to it on the bulletin board. She said, "Let's take a look at our essential questions for this unit, "Today we will focus on the second one, How do images, maps, and models help us understand the Earth system?"

Did the teacher make clear to the students how the activities of this session are related to the essential questions and the unit goals? Describe.

Yes, indirectly. Mrs. X. used the expected outcome of the final project to connect today's activities with an essential unit question.

Did the teacher keep this session "on track" and aligned with unit goals, i.e. avoided "side trips" and tangential activities/discussions? Please describe.

Yes. When team 3 was exploring their image set, they noticed a storm and asked, "How do hurricanes begin?" Students began debating the issue among themselves. Mrs. X. intervened, suggesting they write down the question in the appropriate place on the question sheet. She assured them that they would have a chance to reconsider it later.

Did the teacher use informal methods to check for student understanding during the session? Please describe.

Yes. Mrs. X asked for a thumbs up/down signal at the beginning and at the end of class. She called on students to orally share their recollections of the types of information gathered by satellites. She instructed students to quiz their teammates on image features. She circulated among the teams while they were exploring and analyzing images, providing feedback as needed.

Did the teacher relate today's learning experiences to the culminating performance assessment? If so, please describe.

Yes. In Mrs. X's words, "When your team plans its expedition to your chosen volcano, fault or other unique place, you will need to gather and interpret at least three images or maps. You will need to ask questions about what you see. What we learn today will help you with that part of your final project. Even if your team is planning a trip to the bottom of the ocean, as part of the voting public, you will need to be able to recognize these features when you listen to the presentations from other teams. This will enable you to make an informed decision about whose proposed project should receive funds for further research."

Did the teacher review or reinforce the expectations for the performance assessment?

Perhaps. When Mrs. X mentioned that all students would need to be able to identify features, she reminded them that they would evaluating presentations made by other teams and that they would need to be prepared.

Did the session include learning experiences that build the knowledge and skills that help students explore essential questions and big ideas? If so, describe the activities.

Yes. Students analyzed remote sensed images with the goal of not only identifying features but also of asking questions and gathering evidence of Earth system processes.

Did the teacher elicit student preconceptions or misconceptions and then use this information to guide the work of the session? If so, describe.

Not observed. See discussion below.

During this session, did students and/or the teacher use Web resources? Please describe.

Students used EarthKam images and a NASA Earth from Space dataset during the computer portion of the activity. The volume of these datasets provides a comprehensive resource that lets students explore all over planet Earth. Both Web sites use map interfaces to geographically orient students to the images.

Student Behaviors During this Session

Did students discuss or refer to the essential questions of the unit? If so, please describe.

The majority of students glanced at the essential questions when Mrs. X. pointed to them on the bulletin board.

Did students discuss or refer to the performance assessment? If so, please describe.

A member of team 5 said, "I wonder what kind of vegetation we'll find around our volcano."

Did students relate today's learning experiences to the big ideas? If so, please describe.

Not observed.

Did students seem to be attentive and engaged in the lesson? Describe.

For the most part, students talked to each other about the images they were directed to analyze. Some students were quite animated when quizzing each other. Many teams used a game structure for the quizzing. Some team members spent time socializing. However, all completed the assigned tasks. When students were asked to give a show of hands or thumbs/up down signals, all of them participated.

Did students ask questions or make statements that go beyond fact gathering and that reflect conceptual struggles? If so, please describe.

Not observed. The discussion students had about their images were mostly focused on issues of orientation, geography and identification of features. The questions students turned in on their question sheet may reveal some of these.

Did students demonstrate their understanding (i.e. "I get it! Now I know what you mean by the rock cycle, etc.")? If so, please describe.

Students demonstrated their ability to recognize features. During today's session, they demonstrated their understanding through only one of the facets, the facet of self-knowledge. As they quizzed each other, students made comments like, "I think I can pick these out on other images." Many students nodded their agreement as students identified features on the Buenos Aires image.

Reminder of the facets for later discussion (explanation, interpretation, application, perspective, empathy, self-knowledge)

In this session, were students asked to reflect upon and review essential questions? If so, how was this structured?

They did not review the essential question but did review the main goal of the lesson.

Were the students encouraged to monitor their own progress and learning? If so, please describe.

Students monitored progress within their teams when they quizzed each other.

Reflections on the Session by the Partners

After this session, discuss your observations of this session with your partner. Encourage your partner to interpret and reflect upon their actions. Use this space to record your joint reflections about the session.

Reflection questions:

1. Did the session fulfill the goals the teacher had for it?

2. How could the session have been improved?

When discussing the session, Mrs. X related that she had four goals for the lesson. She hoped students would …

1) understand that images are data that can be analyzed.

2) be to be able to recognize common features they might encounter in remotely sensed images.

3) become familiar with basic geography of the Earth (i.e. location of continents, and major countries).

4) ask questions as an attempt to begin to interpret remotely sensed images.

She did not have enough time to go into depth on goal 4 with students. However, she discussed her intention to guide student questioning to a deeper level where questions focus on the Earth systems. The questions raised by students along with further analysis of images will be the focus of the next session.

In a prior class Mrs. X had elicited preconceptions and misconceptions by showing an image and asking students, "Tell me everything you think you know about this image." She thinks that she may be able to document more misconceptions in tomorrow's session as students begin to interpret why features are where they are."

HANDOUT 21 Implementation Report Guide

For the Spring Conference, each ESBD teacher should prepare a report on the implementation of the unit they created. The implementation report is a way to share your ESBD implementation experience with colleagues. The report should highlight the unit you created and summarize your experience implementing ESBD.

One way to help you get ready for the writing this report is to keep a journal of ESBD related matters, such as thoughts on planning, observations about student learning and reflections that come to you while teaching your unit. You might consider taking notes on your implementation experience organized according to the sections of the report described below.

1. Describing Your ESBD Unit

- Begin with a brief overview of your unit.
- Attach a copy of your Unit Plan to the Implementation Report. This should be the unit as you planned to implement it. Include a printed version of your unit, your rubric, and your pre- and post-assessment quizzes as appendices to your report.
- Attach a copy of your revised Unit Plan. This plan should reflect the sequence of activities that took place during implementation. Include any handouts you created or used during the unit. If you have a lot of materials, you may want to organize them in a three-ring binder.

2. Uncovering Misconceptions

- What misconceptions did you uncover during your unit? Were any of these surprising?
- How successful do you feel you were at addressing these? What might you do differently next time?

3. Building Understanding

- Describe a few strategies you used to help students uncover and build their understanding of your unit concepts.
- Which of the facets of understanding did your unit emphasize? Cite a few examples.
- Describe an activity that you feel really got at deep and enduring understanding.
- Comment particularly on any use of visualizations. How effective were they in helping students achieve understanding? What difficulties, if any, did you encounter in using them?
- What might you do differently in the future?

4. Assessing Student Learning

- Describe the evidence you collected and used to "convict" your students of understanding.
- What was most effective in helping you and them assess their understanding?
- Do you feel your students really developed deep and enduring understanding of your unit concepts?
- Use specific work produced by your students during the unit to illustrate your points.

5. Reflecting on the Implementation Process

- In addition to describing the unfolding of your unit in your classroom, the report is intended to serve as a reflective space for you to share your thoughts about the implementation process. What insights or new understandings have you gained from this experience?
- How have you grown as a teacher?
- How was the experience of doing this ESBD unit different from other Earth science units you have done in the past?
- What issues or questions has ESBD raised for you?
- What advice or guidance might you offer others interested in ESBD?

Please feel free to contact any of the ESBD staff if you need clarification or have any questions.

HANDOUT 22 Spring Conference Presentation Guide

At the Spring Conference we want you to make a brief presentation sharing the results of your implementation of your ESBD unit. Consider this presentation to be along the lines of one you might give at a professional conference. We encourage you to create a tri-fold poster, similar to the sort your students might produce for a science fair. However, you may choose to prepare a PowerPoint presentation in addition to, or instead of, the poster. Your presentation should briefly summarize key aspects of the implementation report. We will have two formats for sharing at the conference; large group presentations and poster breakout sessions. Plan on having about 10 minutes to make your presentation.

Please be sure your poster or PowerPoint includes the following items. (Many of them can just be copied from your Unit Planner.)

- A brief description of the unit
- The unit enduring understandings
- The unit essential questions
- A brief description of the performance assessment
- A description of the evidence that you used to assess student understanding (plus representative student work, if possible)
- Insights you gained or new understandings that you have from implementing ESBD
- Issues or questions that the implementation process raised for you
- Photos of students engaged in the activities of your unit and/or other supporting visuals

Please feel free to contact any of the ESBD staff if you need clarification or have any questions.

HANDOUT 1 Discussion Questions for Building Enduring Understanding in Your Classroom

In small groups, discuss these questions:

1. Describe one activity that you feel really helped move students towards a deep and enduring understanding of the concepts in your unit. Indicate which Enduring Understanding or Essential Question this activity helped students understand.

2. Describe a visualization or Internet resource that you thought helped students achieve a deeper understanding of one of your concepts. Indicate which Enduring Understanding, Essential Question, or skill this activity helped students understand.

3. Thinking about the activities and visualizations that the group has identified, what characteristics make them so effective in promoting deep and enduring understanding?

HANDOUT 2 Guiding Questions for Presentations on Student Understanding

Prepare a 10 to 15 minute presentation that describes the results of your pre and post conception surveys. (20 minutes have been set aside but save 5 minutes for questions and discussion.) You may create a PowerPoint presentation or use overheads. Briefly describe the items on your survey and bring copies of it to share. Analyze your survey data and present key findings. As an example, you may wish to refer back to slides 25 through 39 of Tapping Into Preconceptions (Activity 2 from the Fall Conference). Use the following questions to help guide your presentation.

1. What patterns or themes are evident in the preconception surveys? What models do students hold? Are the ideas revealed here surprising? Can you trace their thinking back to where their ideas may have originated?

2. How do these notions or ideas compare to those exhibited in the post-conception surveys?

3. How did you use the results of the preconception survey to plan or modify your Stage 3 activities in your ESBD unit?

HANDOUT 3 Discussion Questions for Assessing Student Learning in ESBD

In small groups, discuss these questions:

1. How effective was your performance assessment in
    a. allowing you to assess your students' understanding?
    b. allowing each student to demonstrate their understanding?
    c. motivating them to learn?

2. What features or aspects of your performance assessment were most effective in moving students towards deep and enduring understanding? Which facets of understanding came into play in your performance assessment?

HANDOUT 4 Discussion Questions for From Misconceptions to Enduring Understanding

In small groups, discuss these questions

1. Describe any new or surprising misconceptions expressed by students as your unit progressed.

2. Describe specific strategies you used in your unit to move students from their strongly held beliefs toward more enduring understandings. For example, in accordance with the Model of Conceptual Change, how did you

    a. raise student awareness of misconceptions?

    b. help students confront their misconceptions?

    c. help students resolve the differences between old and new understandings?

    d. offer opportunities to extend and make connections between their understandings, other Earth science concepts, and their daily lives?

HANDOUT 5 Presentation Guidelines for Panelists

Prepare a 10 to 15 minute presentation that overviews your topic area.

Use the following questions to help guide your presentation.

1. What is the relationship of your topic to the ESBD approach?

2. What are the major findings from research in this area?

3. Where can teachers learn more about this topic? (i.e. Are there specific journals or websites devoted to the area, coursework that you know of, or other professional development opportunities that you can share?)

HANDOUT 6 Discussion Question for How ESBD has Affected Me as a Teacher and a Learner

1. Think back to how you approached teaching and learning before participating in ESBD and how you approach it now. Describe how your current practice and philosophy of teaching and learning compares with one year ago. What aspects of the program did you do previously? What do you do differently as a result of the program? What is the most important change that has occurred through the ESBD process?