

Science in Context: Helping students develop 21st century skills through issue- oriented science

**Presented by SEPUP
Lawrence Hall of Science
UC Berkeley**



**NSTA PDI
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Presenters

The Science Education for Public Understanding Program (SEPUP)

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Introductions

- On an index card write . . .
 - Your name
 - The subject(s) you teach/specialize in
 - Any experience you have with issue-oriented science instruction
 - What you would like to gain from this session

Overview of the PDI

Morning

What is issue-oriented science?

Design elements

Why use issue-oriented science?

Afternoon

What makes a good issue and

how can issues be incorporated?

Assessing issue-oriented science

21st Century Skills

- Complete the colored worksheet at your seat

21st Century Skills

- Digital Age Literacy
- Inventive Thinking
- Effective Communication
- High Productivity

21st Century Skills

Digital-Age Literacy

- Basic, Scientific, Economic, & Technological Literacy
- Visual & Informational Literacy
- Multicultural Literacy & Global Awareness

Inventive Thinking

- Adaptability, Managing Complexity, & Self-Direction
- Curiosity, Creativity, & Risk Taking
- Higher-Order Thinking & Sound Reasoning

21st Century Skills

Effective Communication

- Teaming, Collaboration, & Interpersonal Skills
- Personal, Social, & Civic Responsibility
- Interactive Communication

High Productivity

- Prioritizing, Planning, & Managing for Results
- Effective Use of Real-World Tools
- Ability to Produce Relevant, High-Quality Products

What is Issue-Oriented
Science?

Reclaiming the Metal: An Issue-Oriented Science (IOS) Activity

From the unit *The Chemistry of Materials*, from
SEPUP's middle school physical science course
Issues and Physical Science

Reclaiming the Metal

Activity Context

- *Reclaiming the Metal* falls in the middle of a series of lessons on the chemistry of materials
- In this activity, students investigate the reaction rate of a series of chemical reactions with a copper compound and use the information to answer the question:
How should we handle copper waste?

IOS Activity: Reclaiming the Metal

- Challenge

- Which metal is best at reclaiming copper from the used copper chloride solution?

- Investigate

- Compare the reactions of copper waste with three different metals —zinc, iron, and aluminum.

- Procedure

- Appropriate safety precautions
- Place copper waste in waste containers
- Instead of forceps, use a spoon

Evaluating the Results of the Investigation

- Answer Analysis Question 3

- Note: Analysis Question 3 is an ET Assessment. We will return to this in the afternoon session.

- Informal meeting of the minds: compare your evidence and conclusions with those of two other people. Record the ways your evidence and conclusions are similar and different.

IOS Activity: Reclaiming the Metal

- Clean-up

- Put extra plain water back in pitchers on back table
- Put waste water in small cups in box top on back table
- Put paper towel and washers in trash can in back
- We encourage you to wash your hands during the break

Reclaiming the Metal

- What were students learning in this activity?
- What was the issue?
- How was the issue incorporated in the activity?

Mid-morning Break

The PDI will resume promptly in

15 minutes

IOS Design Elements

What are the major goals of
Issue-Oriented Science?

Goals of issue-oriented science

- To engage all students in the process of learning science
- To encourage and prepare students to use scientific evidence to make decisions
- To help educate tomorrow's citizens about the application of science to everyday life
- To develop scientifically literate citizens

Reflection on IOS Activity

- In your group please discuss the following:
 - In what ways do you think an IOS classroom might be different from a traditional (non-inquiry, non-IOS) classroom?
 - How might 21st Century skills be incorporated in an IOS classroom?

Characteristics of the IOS Classroom

Less Emphasis On	More Emphasis On
Discussing science in isolation	Discussing science concepts and understanding in the context of personal and societal issues
Working alone	Working with a group that simulates the work of a scientific community or policy group
Acquiring scientific information	Acquiring conceptual understanding and applying information and conceptual understanding in making personal, societal, and global decisions
Testing students for understanding at the end of the unit	Embedded assessments throughout the unit and culminating assessment activities
Closed questions with one correct answer	Open-ended questions that require students to explain phenomena or take positions backed by evidence

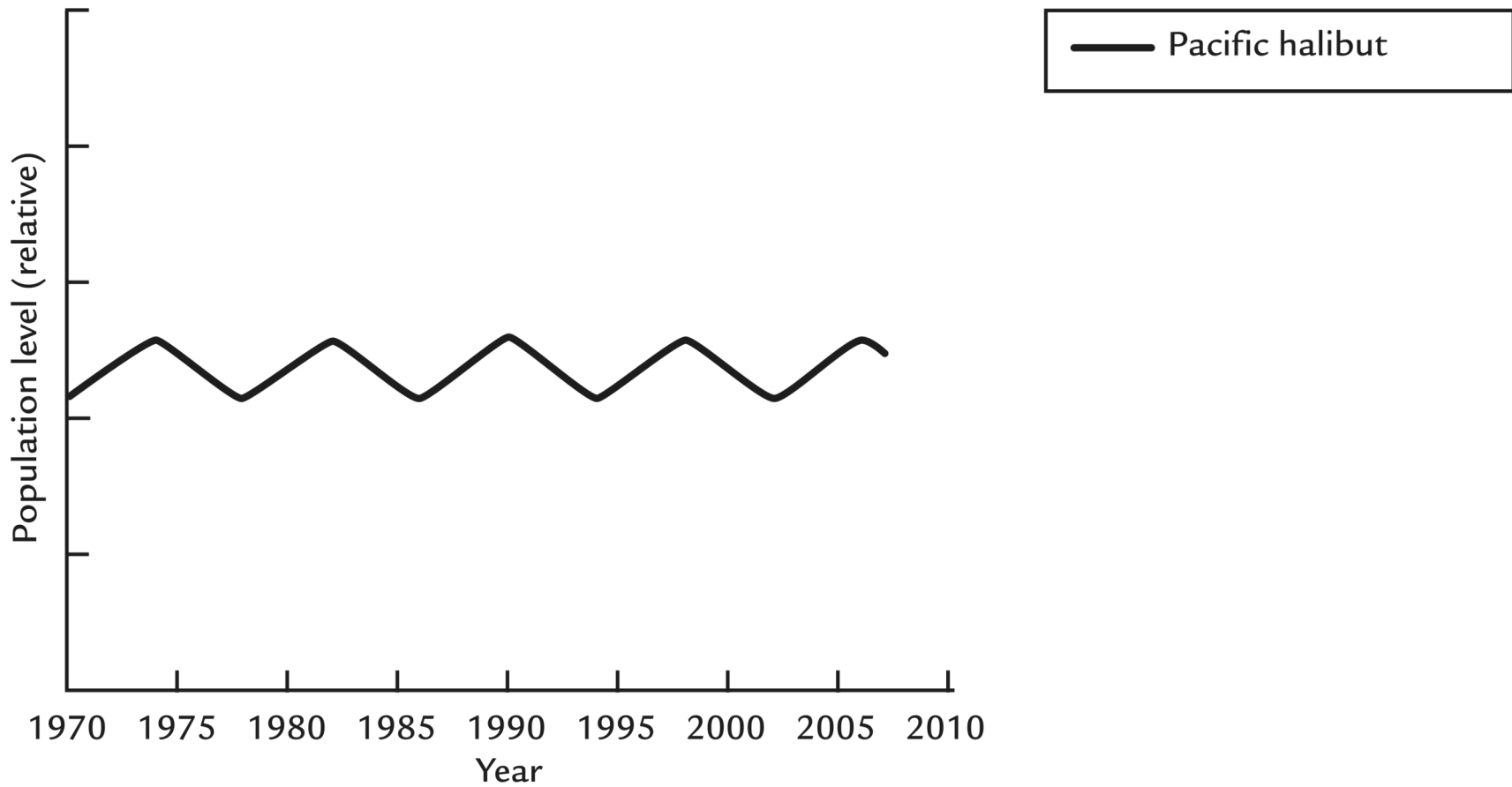
Characteristics of the IOS Classroom

- Use of strategies that support inquiry
 - Teacher as facilitator
 - Group and class discussions
 - Research
 - Role-playing
 - Scaffolding and differentiated instruction
 - Process skills used in context
 - Questions to guide discussions
- Coherent flow of both content and issue
- The issue drives the lessons and is not an add-on

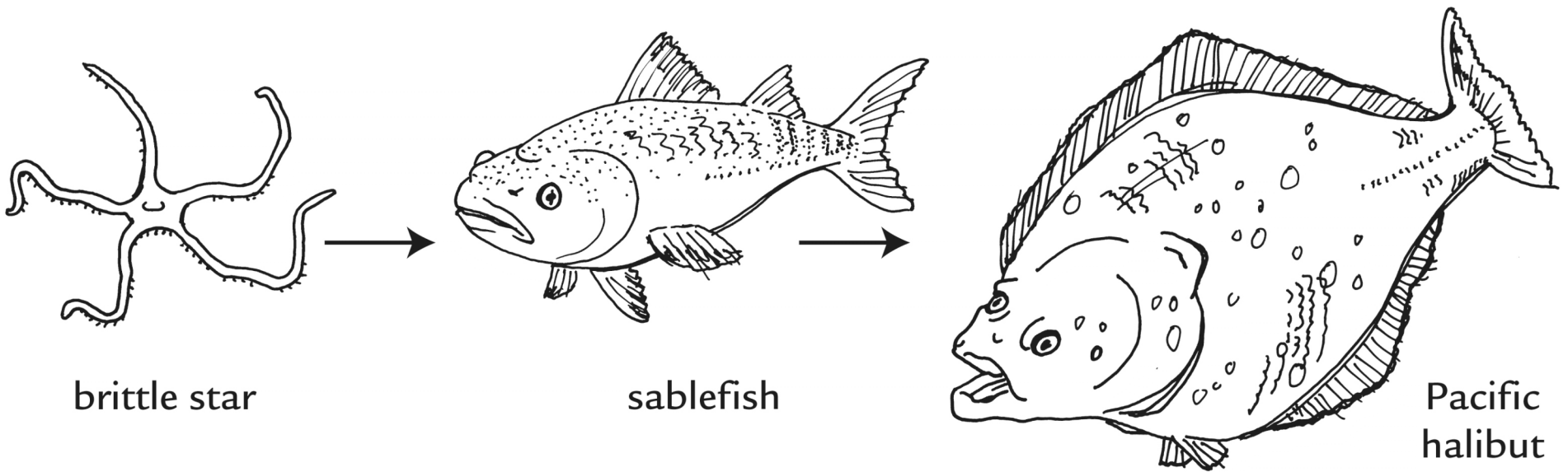
Ecosystems Out of Balance

- From SEPUP's high school life science course *Science & Global Issues: Biology*
- Occurs near end of unit (16 out of 19)
- Students have developed understanding of:
 - Basic ecosystem dynamics
 - Photosynthesis & cellular respiration
 - Cycling of nutrients
 - Population dynamics

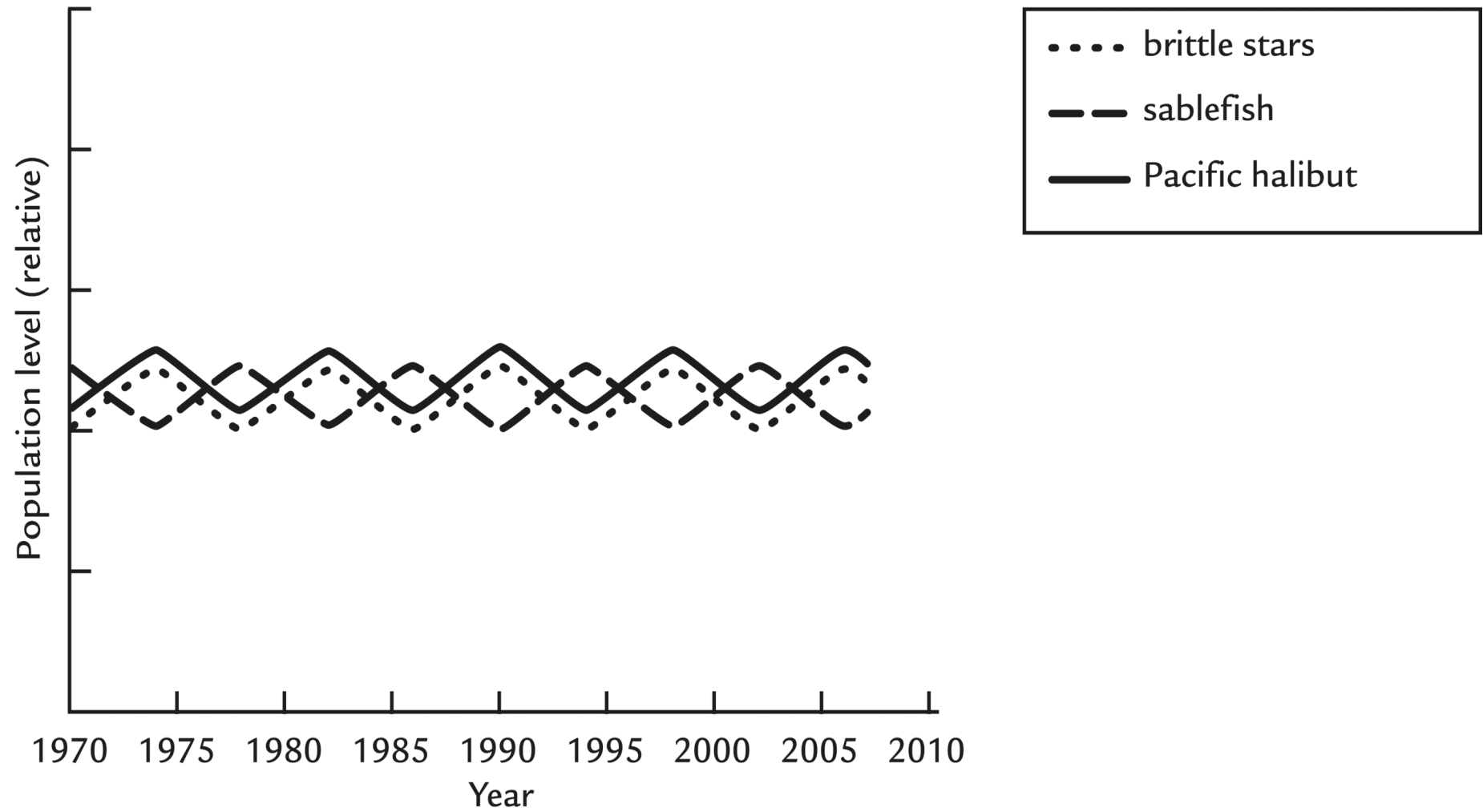
Pacific Halibut Population



Pacific Halibut Food Chain



Pacific-Halibut-Dominated Ecosystem



Understanding by Design

- Begin with the end in mind

- What will students know, understand, and be able to do as a result of the unit or lesson(s)?

- What evidence will show what students know, understand, and are able to do?

- How best will students learn the material?

Developing IOS Instructional Materials

1. Select a content area.
 - Articulate learning targets
 - Include content and process targets
2. Select a relevant issue.
 - Evaluate the issue (afternoon session)
 - Articulate learning targets for the issue
3. Consider what prior knowledge will be required.
4. Consider the flow of concepts and issues if designing several activities or a unit.

Developing IOS Instructional Materials

5. If designing a unit or sequence of activities, develop an outline that includes the content, type and length of activity, and assessment opportunities. Look for balance.
6. Design and test the individual learning experiences, paying attention to the resources available. Use a variety of questions to drive the activities.

Why use issue-oriented
science?

Why use issue-oriented science?

- Integrates sciences and integrates science with other subjects, portraying a realistic view of how science contributes to solving problems and of the role of science in careers.
- Makes real-world connections and shows students how science is useful in daily life.
- More authentic science, for ALL students.
- It helps students in learning science.
- It helps improve attitudes of students towards science.

Policy

- National Science Education Standards (NRC, 1996)
 - Standard F: Science in Personal and Societal Perspectives
- Benchmarks for Science Literacy (AAAS, 1993)
 - For example:
 - Standard 1c: The Scientific Enterprise,
 - Standard 3: Technology and Science
 - Standard 7: Human Society
 - Standard 8: The Designed World
- NSTA Position Statements

NSTA Position Statement: Beyond 2000—Teachers of Science Speak Out

Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. *Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it.* Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. (NRC, 1996, page 22)

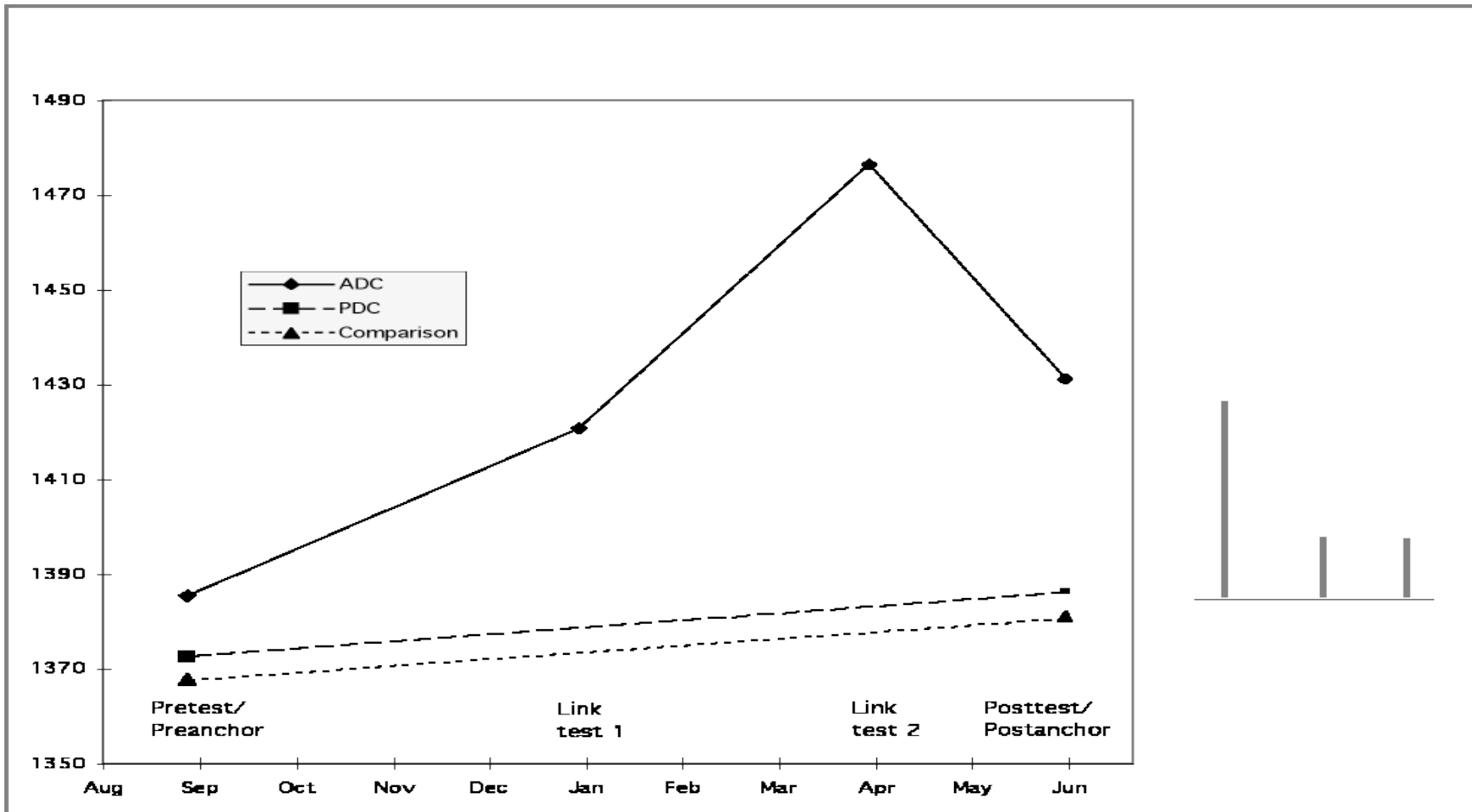
<http://www.nsta.org/about/positions/beyond2000.aspx>

NSTA Position Statement: Teaching Science and Technology in the Context of Societal and Personal Issues

NSTA strongly promotes the education of a citizenry that is scientifically and technologically literate as defined in the National Science Education Standards (NRC 1996). This requires that we not only know, understand, and value scientific and technological concepts, processes, and outcomes, but that we are able to use and apply science and technology in our personal and social lives (Zeidler 2003).

<http://www.nsta.org/about/positions/societalpersonalissues.aspx>

Student Outcomes: Learning in IEY Wilson and Sloane (2000)

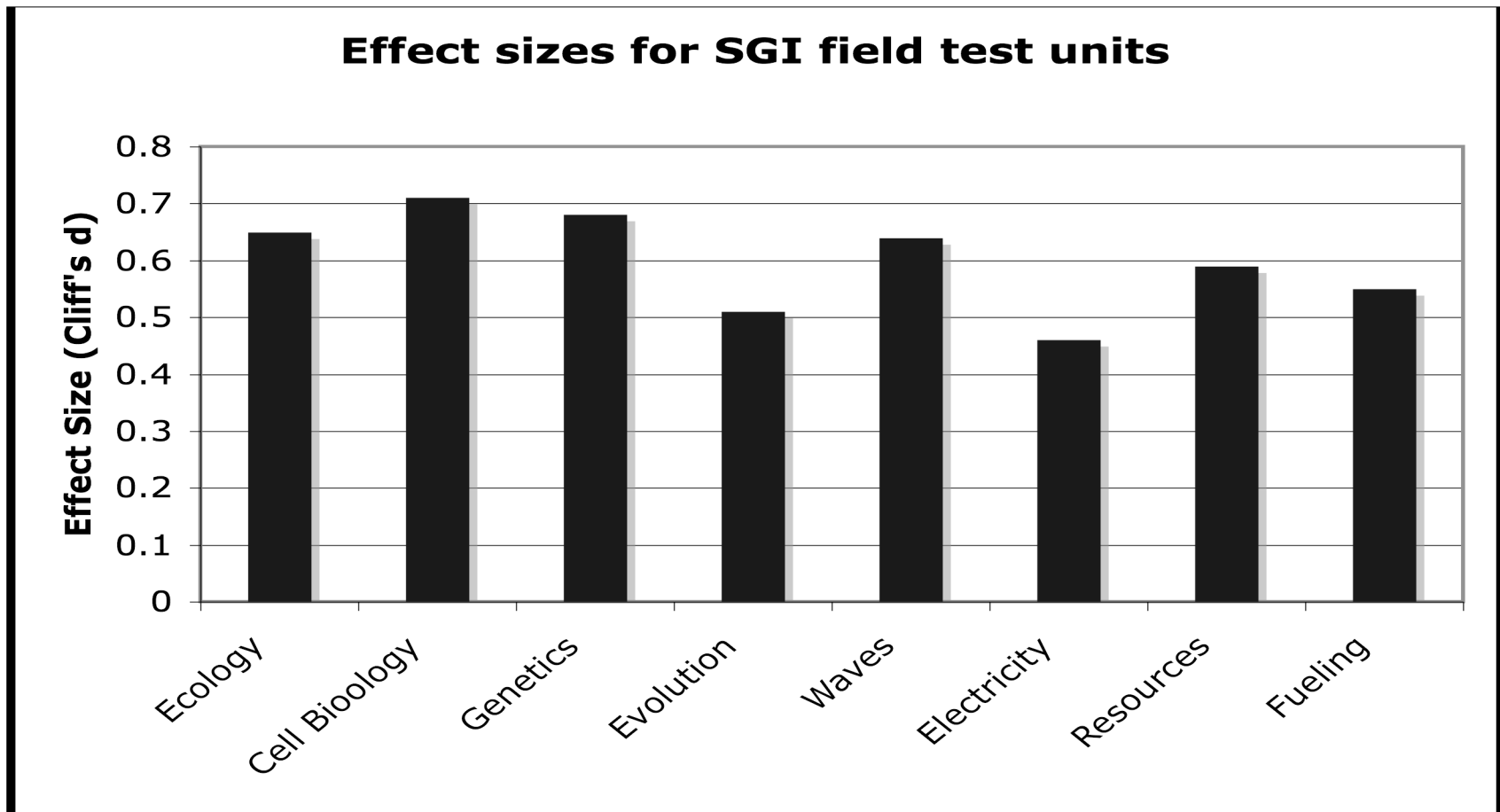


Effect Size by Unit

Unit	Effect Size
Studying Soil Scientifically	.69
Shaping the Land	.67
Rocks and Minerals	.48
Plate Tectonics	.64
Weather and Atmosphere	.62
The Earth in Space	.80
Space Exploration	.69

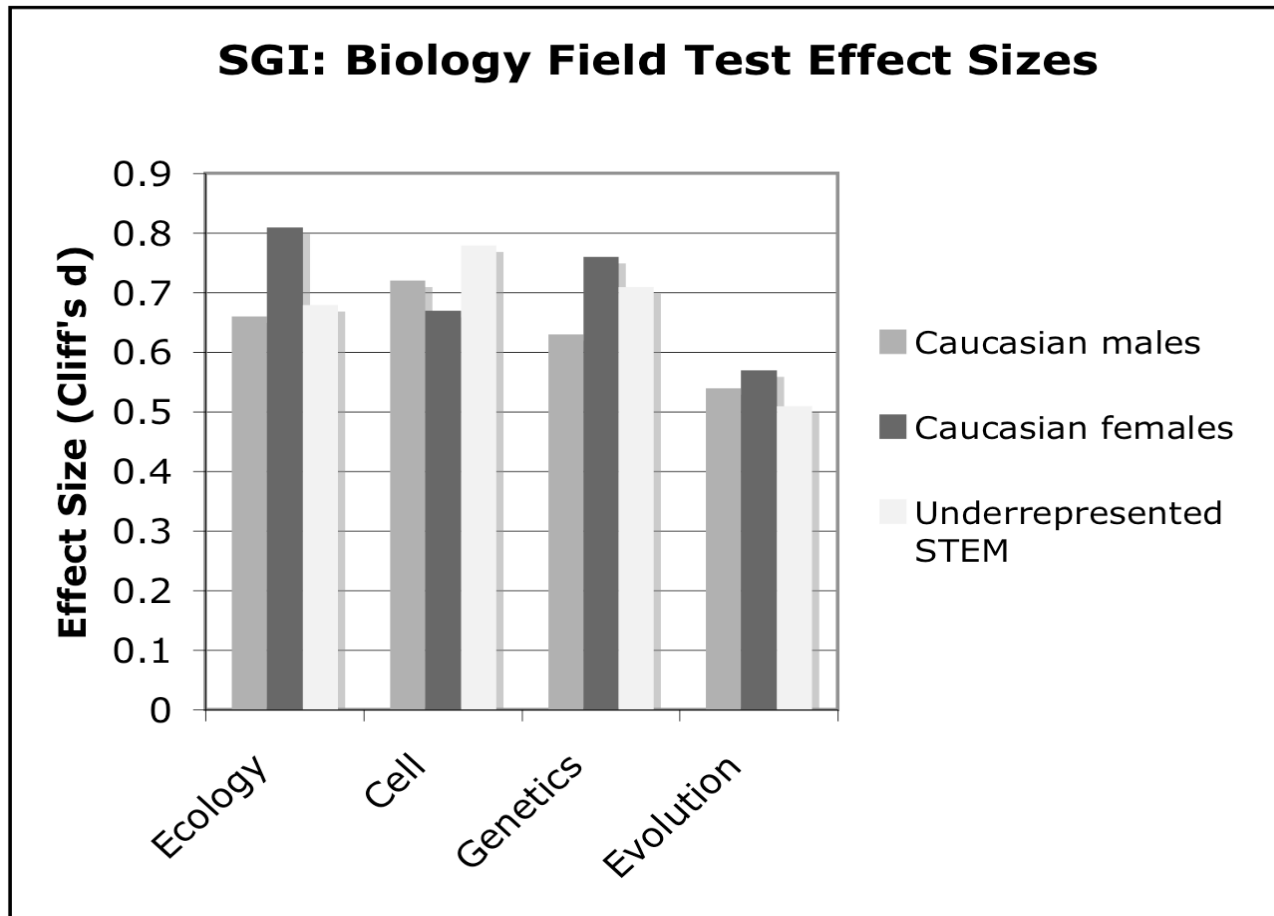
Cohen's d large effect size is over 0.80; Moderate effect size is over 0.5

Science and Global Issues



Small effect size Cliffs $d = 0.147$; medium effect size Cliffs $d = 0.330$;
large effect size Cliffs $d = 0.474$ (Cliff, 1993; Romano et al, 2006)

SGI Biology Field Test



Reflection

What questions arose this morning?

Write your questions on an index card and we will do our best to answer them this afternoon.

Lunch

Afternoon session starts
promptly at 1:00

Incorporating issues into science activities

The Full Course

From the unit, “Cell Biology and Disease,”
from SEPUP’s middle school life science
course, *Issues and Life Science*

The Full Course Activity Context

- *The Full Course* falls late in the Cell Biology and Disease unit from *Issues and Life Science*, SEPUP's middle school life science course.
- Students have studied cell structure and function, microbes, causes of disease, and disease prevention.
- In this activity, students investigate how a population of bacteria is impacted when a patient does not take the full course of prescribed antibiotics.

The Full Course

- Challenge

- Why is it important to take an antibiotic as prescribed?

- Investigate

- Examine how the proportions of different types of bacteria change in a population.

- Procedure

- Count out the plastic chips as per Procedure Step 1.

- Roll the die & use the table to adjust the number of chips.

- Allow the bacteria to reproduce! (Procedure Step 3)

- Repeat until 8 days has passed.

- Graph the results.

The Full Course

- What is the content?
- What is the issue?
- Examine the version of this activity without the issue.

Types of Issues

- Issues can range from personal to societal.
- Societal issues can be focused at the community and/or global level.

Examples of personal issues

○ Would you choose to buy a mined or manufactured diamond?

○ Would you take this new medicine?

○ Would you choose to drink bottled water or tap water?

○ Which car would you buy if your primary concern was safety in a crash?

Examples of societal issues

- What space missions should be funded from a limited budget?
- What is the most effective way to reduce heart disease?
- How should society encourage energy efficiency?

What makes a good issue?

Criteria for Evaluating Issues

The strongest issues:

- Require knowledge and understanding of important scientific concepts and processes
- Require an application of relevant scientific evidence
- Relate to scientific concepts and processes appropriate to grade level and subject matter
- Engage diverse groups of students
- Are complex enough to foster discussion and debate (Is there more than one solution or response?) OR clearly illustrate how science can inform a decision.

Other considerations

You might also include issues that:

- Are in the news
- Are especially relevant to the age group
- Illuminate the difference between the evidence that science can provide and the social aspects of the decision

Is the issue engaging to diverse groups of students?

- Consider your audience
- Factors affecting this are:
 - Geographic location
 - Socioeconomic background
 - Urban, rural, vs. suburban
 - Gender
- When you use issues:
 - Make local connections
 - Include a variety of personal and societal issues
 - Engage students in an issue with a scenario that helps them identify with others

Some questions relate to many issues

- How strong is the evidence in support of this position or decision?
- Is “it” safe enough?
 - How can it be made safer?
- How can we balance human needs and environmental protection?
- What is the best way to use limited resources?

How can issues be incorporated in science lessons?

Choose one of the following to examine:

- IALS 51 “The Full Course”

- IAPS 67 “Hot Bulbs” (compare to no-issue version)

- IAES 52 “Local Weather History”

- SGI Cell Biology 13 “The Cell Cycle”

Identify how the issue is incorporated into each of these activities.

Some ways to incorporate issues

- Lab or activity
 - e.g. - tasting or testing different water samples
- Analyzing data
- Reading and discussion
 - Stories about events that have happened
- Role plays/skits
 - Scripted, typical conversations
 - Different roles with different perspectives
- Debates
- Position statements

Introduce an issue with a scenario

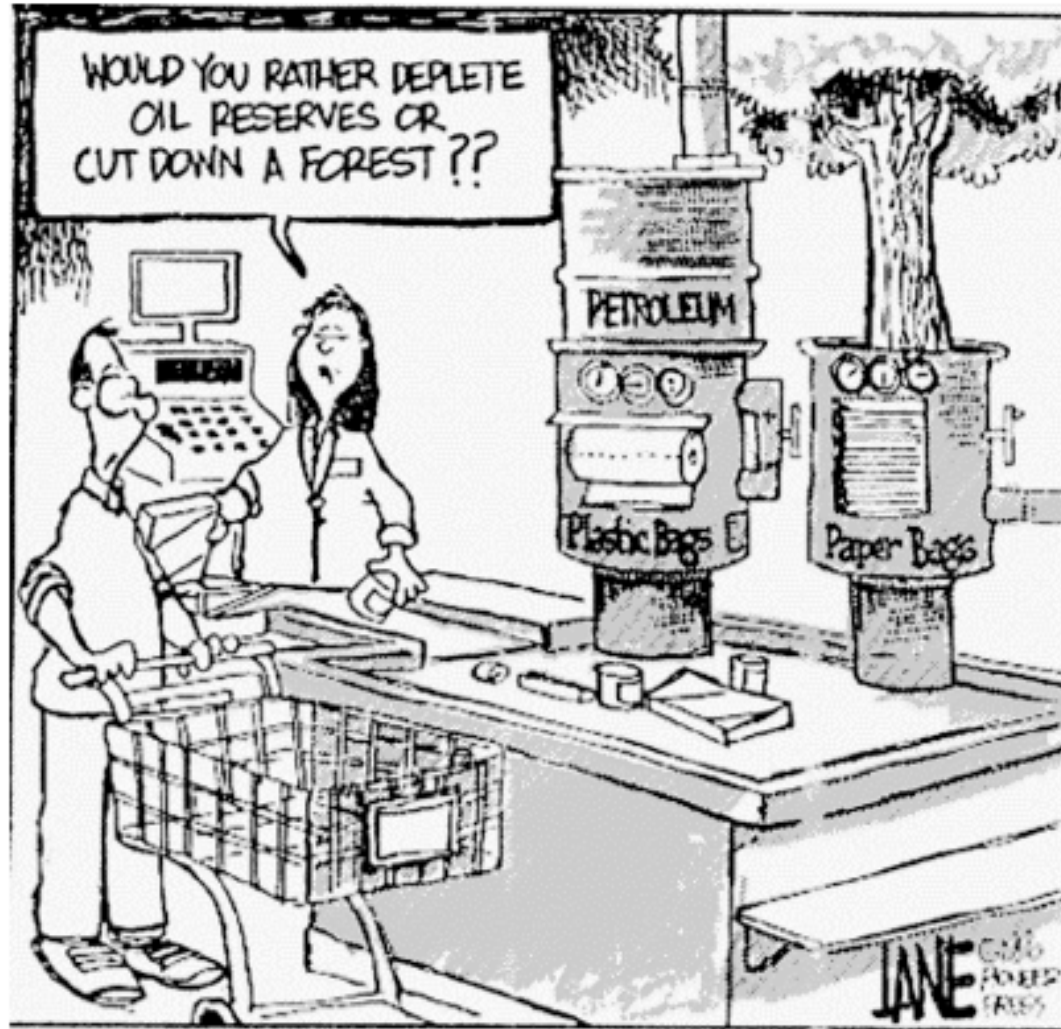
2003 REGENTS OF THE UNIVERSITY OF CALIFORNIA



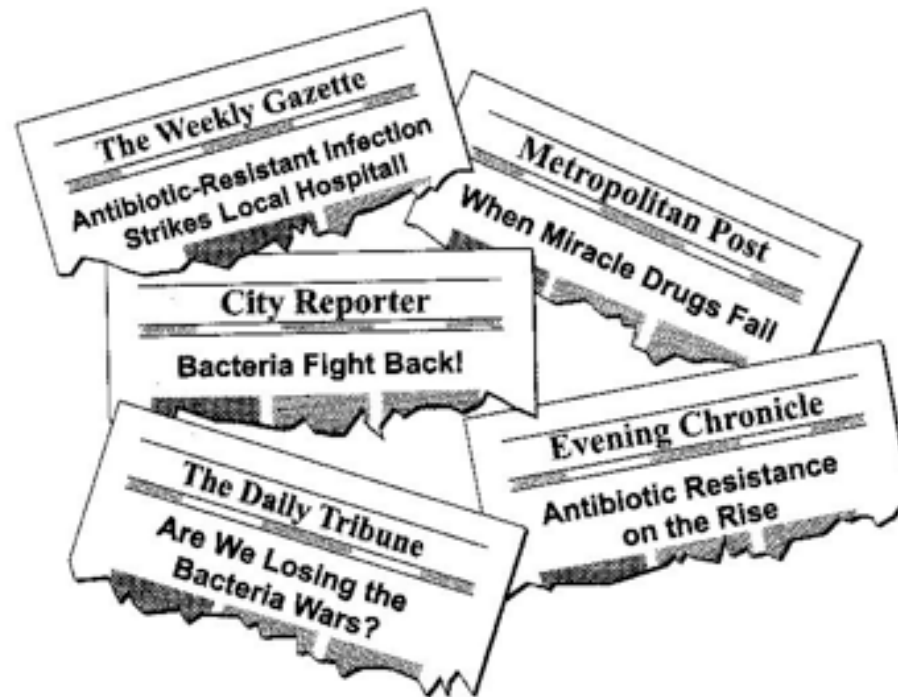
Sara's Old Computer

TRANSPARENCY 1.1

Introduce an issue with a cartoon



Introduce an issue with news articles or headlines



CHALLENGE →

What happens when antibiotics are overprescribed or used improperly?

Assessing Issue-Oriented Science

What are you assessing?

- In science
- In inquiry-oriented science
- In issue-oriented science

SEUP Scoring Rubrics

- Content
 - Understanding Concepts
- Process
 - Organizing Data
 - Designing Investigations
 - Analyzing Data
- Making Evidence-Based Decisions
 - Recognizing Evidence
 - Evidence and Trade-offs
- Communication
 - Organizing Scientific Ideas (SI)
 - Communication Skills (CS)
- Group Interaction

Scoring Guide :

Evidence and Trade-offs

Level 4 Above and beyond	Student accomplishes Level 3 and goes beyond in some significant way.
Level 3 Complete and correct	Student compares options using accurate and complete evidence and takes a position supported by the evidence. Student describes trade-offs of his/her decision.
Level 2 Almost there	Student discusses one or more options using accurate or relevant evidence and takes a position supported by the evidence BUT reasoning is incomplete and/or part of the evidence is missing.
Level 1 On your way	Student takes a position BUT provides reasons that are subjective, inaccurate, or nonscientific.
Level 0	Student's response is missing or irrelevant.

Score Student Work

1. Working alone, use the ET Scoring Rubric to score the work of Students A, B, and D. You can score more students if you have time.
2. After everyone in your group has finished scoring A, B, and D, record each group member's score on the moderation form.
3. Discuss the score you gave each paper, and try to reach consensus based on the ET Scoring Guide.

Scoring Guide :

Evidence and Trade-offs

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Level 0	Student's response is missing or irrelevant.

Assessing IOS

- Use the Evidence and Trade-offs (ET) rubric to revise your answer to Analysis Question 3 from this morning's activity on copper waste.
- What was this experience like?
- Was this a good assessment question?
 - Explain

What are the challenges to this kind of assessment?

Scoring reliability

- Moderation
- Set specific criteria, related to the scoring guide, for each assessment

Assess One Variable at a Time

- Unidimensionality: A single score represents a single dimension or trait that has been assessed

Lack of Unidimensionality

	Dimension A	Dimension B	Total Score
Student 1	2	10	12
Student 2	10	2	12
Student 3	6	6	12

Marzano, R. J. (2006) Classroom Assessment & Grading that Work. (pp. 14–15)

Writing good ET questions

- Open-ended: more than one possible correct answer
- Try writing a Level 3 answer (or several answers) yourself
- Discuss with other teachers
- Try out with a class
 - Look for a range of answers
 - Be sure at least some students are able to write a Level 3 answer

Final Thoughts on Assessment

- Share rubrics with students
- Provide multiple opportunities for students to become familiar with the rubrics
- Have students practice writing answers
- Provide specific feedback on performance
- Consider self- and peer-scoring
- Use what you learn from assessments to adjust instruction

Quick write

How will you incorporate the following into your curriculum:

Issue-oriented Science?

21st Century Skills?

Conclusion

- Rigor of issue-oriented science depends on selection of appropriate issues
- Issue-oriented science incorporates opportunities for students to develop 21st century skills
- Issue-oriented science engages a broad spectrum of students
- When using issues, think carefully about how to present them and how to structure the curriculum to encourage use of scientific evidence, processes, and concepts in discussions and decisions about issues.

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This Power point presentation and all handouts will be posted on the SEPUP website the week after the meeting at <http://www.sepuplhs.org/news.html>

(Click on “SEPUP Workshop Materials Available for Download”)