

Redesigning Large Classes for Learning

Active Learning Strategies for Introductory Geology Courses



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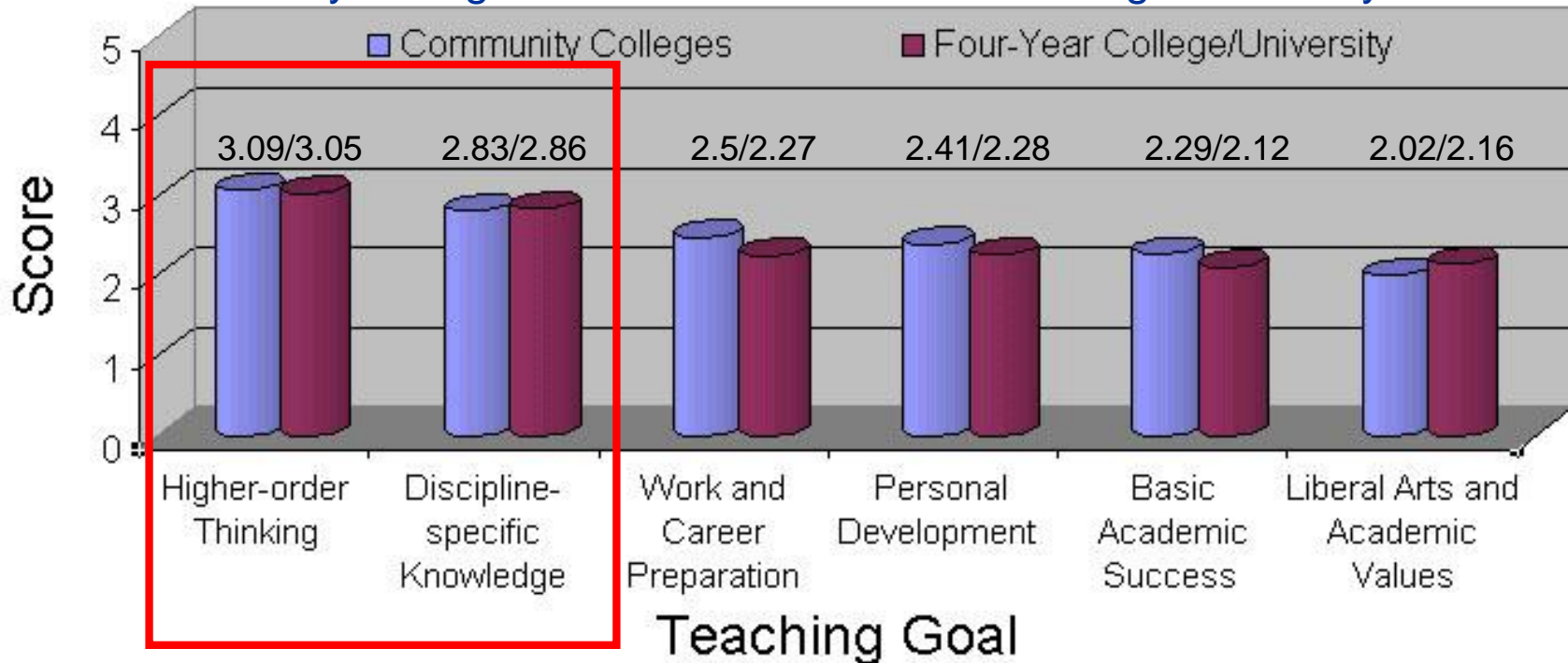
What are our teaching goals?

Teaching Goals Inventory

Angelo & Cross, Classroom Assessment Techniques (1993)

Community Colleges: n = 1873

Four-Year College/University: n = 951



TGI is available on-line at: <http://www.uiowa.edu/~centeach/tgi/index.html>

How can we Assess Thinking Skills?

We wanted to find out if we could:

- i. . . determine if students are prepared to use higher-order thinking skills.
- ii. . . teach a general education class in which students improve their higher-order thinking skills and conceptual understanding.
- iii. . . identify strategies that others can use to assess ongoing student learning.

The Gardener Metaphor

A good gardener will:

- Know the characteristics and needs of plants
- Place each plant in the appropriate location
- Provide plants with sufficient water, nutrients for growth
- Monitor plantings regularly and make adjustments

An effective teacher will:

- Know the characteristics and needs of their students
- Place students in appropriate learning environment
- Provide students with sufficient conditions for intellectual growth
- Monitor student learning regularly and make necessary adjustments

Student Cognitive Development

Concrete Operational Students

- Focus on memorization.
- Use working memory ineffectively
- Little consistency between answer and question.
- Apply inappropriate concepts.
- Provide incomplete answers.

Formal Operational Students

- Capable of abstract thought.
- Deep working memory
- Match concepts accurately with questions.
- Responses connect multiple relevant variables
- Use logic, inferences when constructing answers.

Who are we teaching?

GALT test - **G**roup **A**ssessment of **L**ogical **T**hinking
12 question instrument (score 0-12)

Scoring Categories

- **Concrete (0-4)** - prefer fact-based approach, rely on memorization (24%)
- **Transitional (5-7)** - prefer to apply ideas in a practical way (33%)
- **Formal (8-12)** - abstract thinkers, can understand previously unseen ideas (43%)

http://faculty.cua.edu/bunce/BCCE/GALT_test.doc

Implications for Teaching

A majority of students are unprepared to understand abstract concepts presented in introductory science class without appropriate “scaffolding” activities.

Students are not younger versions of us:
Teaching strategies must be designed for all students, not just those who are already formal (abstract) operational thinkers.

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Appropriate Learning Environment

A Learner-centered Class

- Lecture broken into short segments, separated by assessments
- Students work together in groups
- Formative exercises during class used to assess student understanding and progress



Assessment for Intellectual Growth

Teaching and learning goals can be ordered using **Bloom's Taxonomy**

Knowledge	memorization and recall	Text
Comprehension	understanding	Conceptests (Peer instruction)
Application	using knowledge	Venn Diagrams
Analysis	taking apart information	Concept Maps
Synthesis	reorganizing information	Evaluation Rubrics
Evaluation	making judgements	

Open-ended questions can be used for all categories.

Monitoring Student Learning

Plate Tectonics Comprehension Survey: Link learning goals with specific exercises for conceptual understanding.

Level 1: I can identify how many plates are present on a map showing plate boundaries (comprehension).

Level 2: I can draw a cross section to illustrate the characteristics of plate boundaries (comprehension).

Level 3: I can compare and contrast the features associated with divergent and convergent plate boundaries (analysis).

Level 4: I can interpret how plate configurations change over time. (synthesis).

Example: Earth Science Concepttest

Examine the map and answer the question that follows. How many plates are present?

a. 3 (26%; 0%)

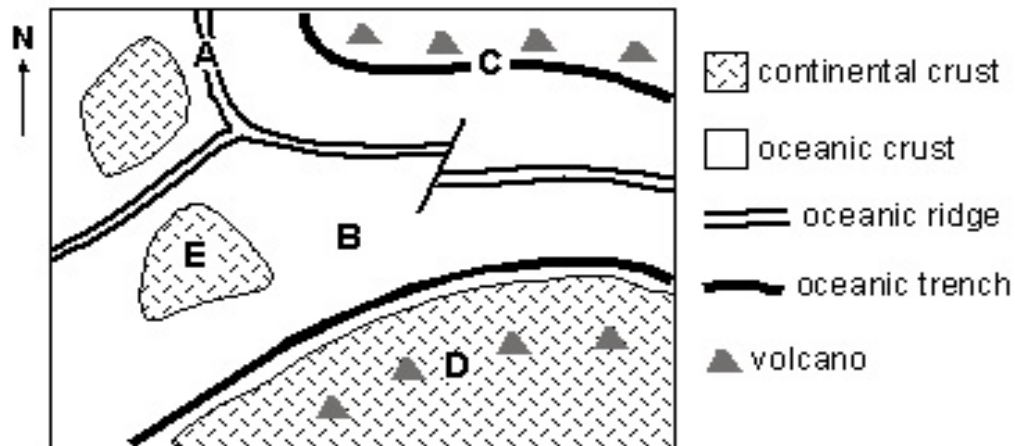
c. 5 (44%; 75%)

b. 4 (19%; 18%)

d. 6 (11%; 7%)

Individual responses

Post-discussion responses



**Results when
using physical
models:
(56%; 84%)**

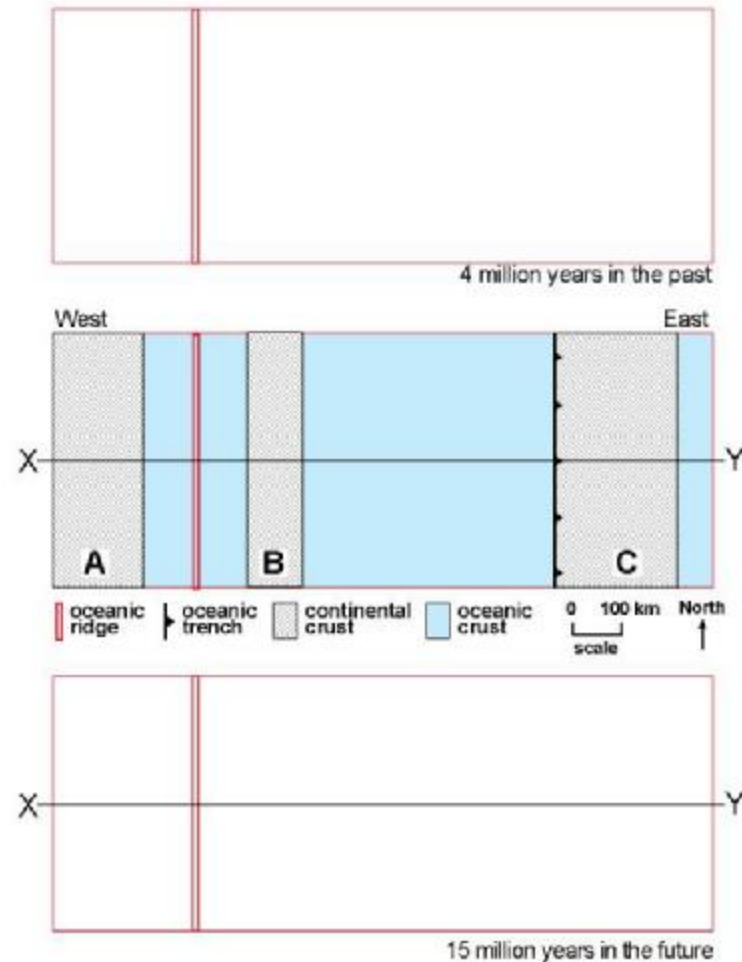
Geology concepttest database :
[http://serc.carleton.edu/introgeo/
interactive/conctest.html](http://serc.carleton.edu/introgeo/interactive/conctest.html)

Example: Change over time

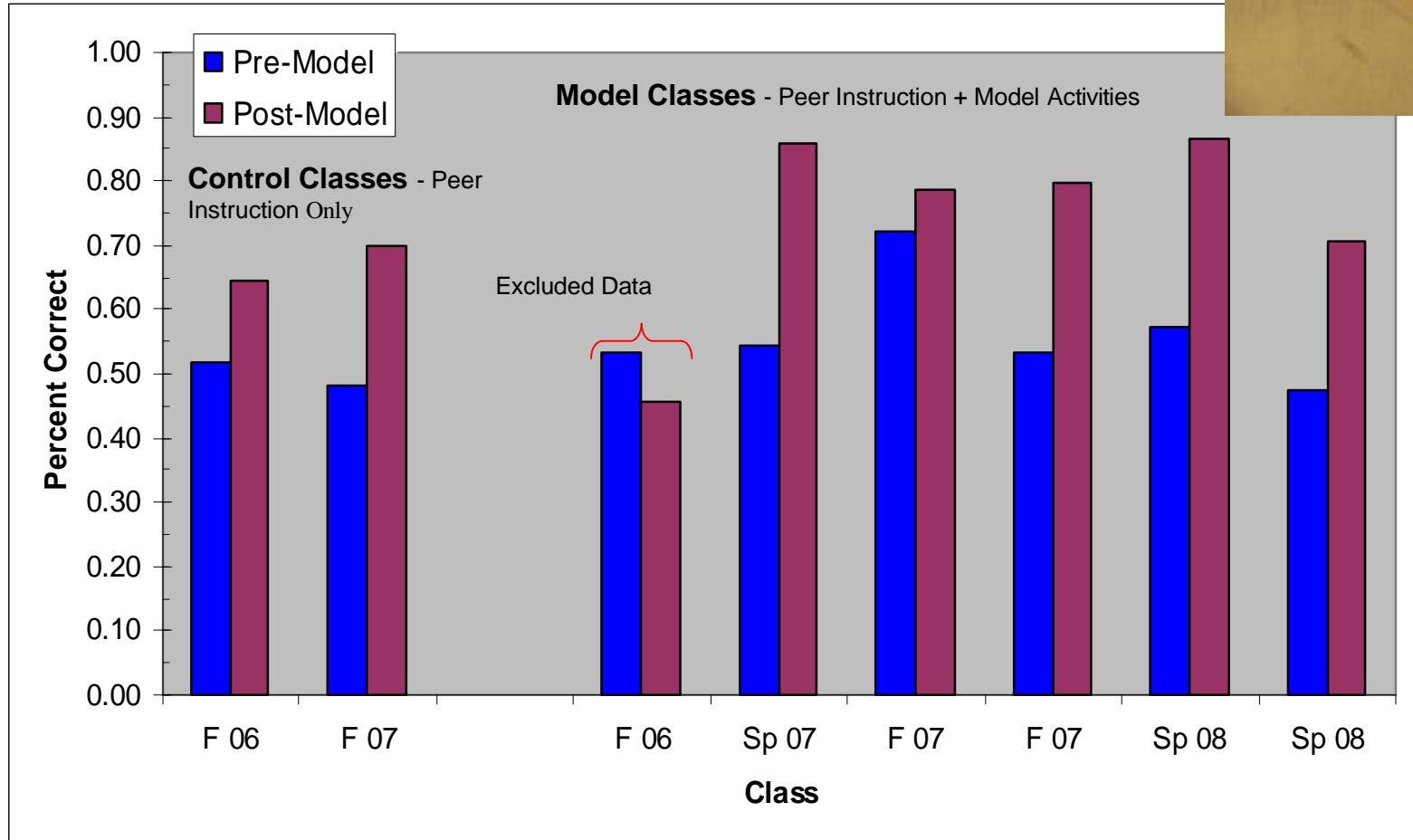
Synthesis

A and B are traveling at 5 cm/yr; C is traveling west at 2 cm/yr.

1. How many plates are present?
2. Sketch and label a cross section along X-Y.
3. Fill in the upper and lower templates to show the plate configurations.



Students and Seasons Model



Students and Models

Sample student comments

- [The model gave] me a visual aid and helped me understand it better than just telling me about it. -
- When I see it [the model], it makes more sense to me. Because it just puts a picture in my head, and then when I go to take the test, I can see it [the picture of the model] in my head. I can see it moving or tilting... I got pictures in my head that way, rather than just definitions.

Improvement in Thinking Skills

Points gain in GALT score vs. Course Structure

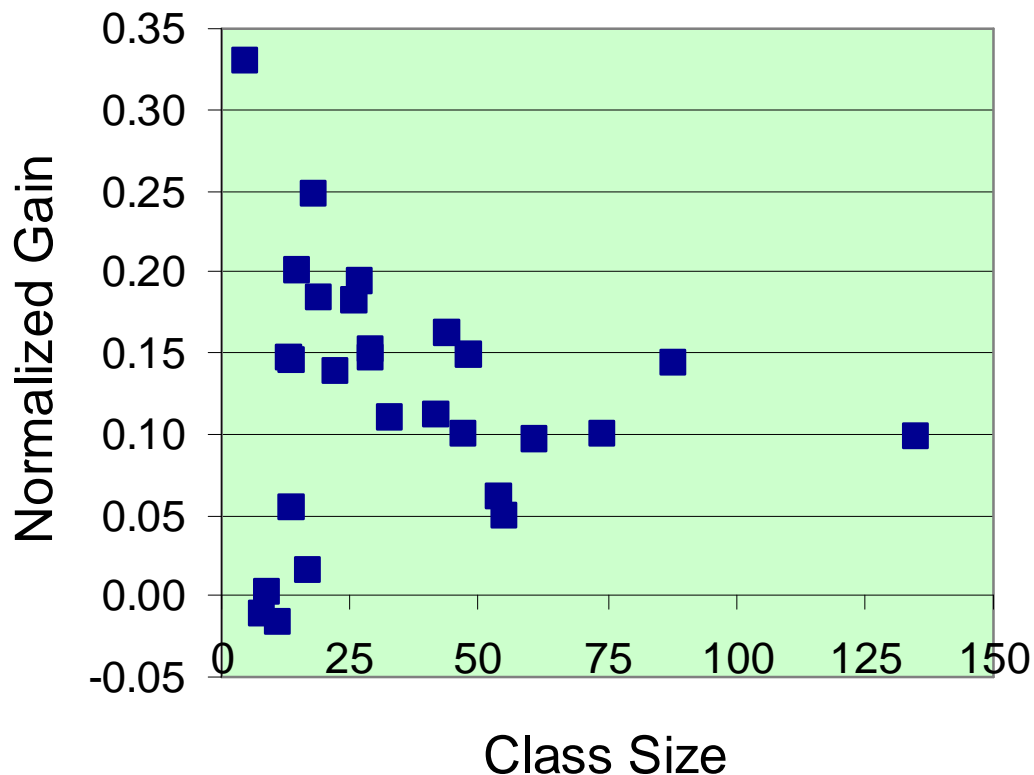
Active Learning, n=465

GALT score 0 - 4	GALT score 5 - 7	GALT score 8 - 12	Normalized Gain
2.1	1.2	0.2	18%, $p < 0.001$
1.2	0.6	-0.2	9%, $p < 0.001$

Traditional Lecture, n=276

Improvement in Conceptual Understanding

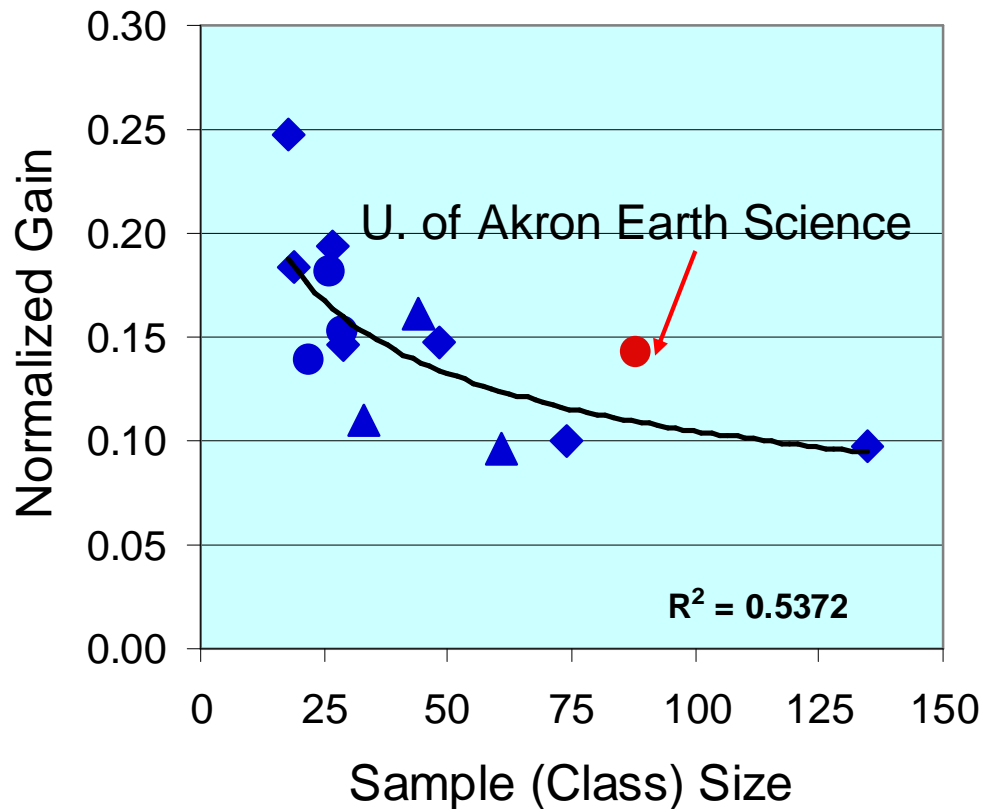
Paired Class Size vs. Normalized Gain (all classes)



- **How do we know if students have learned?**
- Normalized gain scores for 27 introductory geoscience classes (data from Libarkin and Anderson)
- Results averaged for paired GCI surveys for 957 students
- Range, -0.017 to 0.33
- **What is a “good” gain?**

Improvement in Conceptual Understanding



Paired Class Size vs. Normalized Gain ($p < 0.01$)



- 14 of 27 classes show **significant gains** ($p < 0.01$) from pre to post-test
- Trend of decreasing gain score with increasing class size
 - Circles – classes with less than 50% lecture
 - Triangles – classes with more than 70% lecture
- **Threshold gains of 0.15 for small classes, 0.1 for large classes**

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Best Practice: The Books

344

Checkpoint 12.18

A farmer drilled a well into an open aquifer composed of sand and gravel. He installed a septic system down slope from the drinking well (see diagram). After a few years, he noticed that the septic system had begun to leak. Water tests showed that the well water was clean and uncontaminated by bacteria present in the septic system. Why did the septic system not contaminate the drinking water supply?


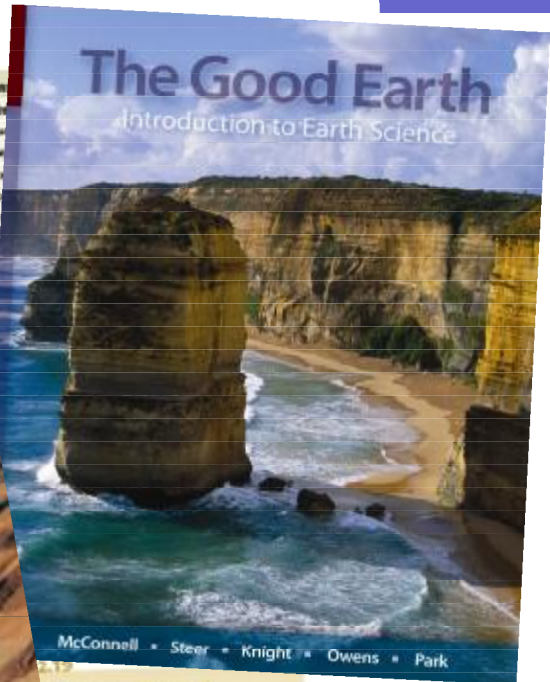



Table 12.1 Com

Contaminant	Health
Asbestos	Cancer
Chromium	Cancer
Lead	Neurotoxicity
Organophosphates	Neurotoxicity
Polychlorinated biphenyls (PCBs)	Cancer
Radon	Cancer
Trichloroethylene (TCE)	Cancer
Uranium	Kidney damage



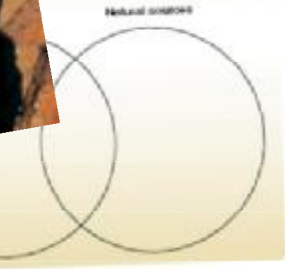
New geoscience texts with pedagogical tools to foster student learning and the development of higher-order thinking skills

Review the following answers and questions to 7, with 1 the most important.



Human and Natural Contamination Compared

provided here to compare and contrast pollution from human action (e.g., agricultural runoff) and pollution from natural sources (e.g., volcanic ash). Features unique to either group in the left and right circles; note features they share in the center of the image.



Provide a framework for instructors seeking to use active learning strategies

Next Steps

1. Literature review reveals few articles detailing validated student learning gains across introductory geoscience courses.
2. Scholarship has focused on learning of individual concepts (geocognition) or with learning in specific settings (lab, field).
3. Teaching resources, text books, professional development readily available (e.g., <http://serc.carleton.edu/introgeo/index.html>).
4. Need to determine benchmarks for student learning of concepts (GCI) and for discipline specific higher order thinking skills.
5. Need to establish which pedagogical strategies are most effective in different class settings. Extrapolating from other STEM disciplines may not serve needs of geoscience students.