Using Bloom's taxonomy to match teaching goals and learning exercises

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&

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Bellflower, 11:00 - 11:50am, June 27

Preparing for an Academic Career in the Geosciences Workshop

Introductory Exercise

1. Examine the six questions below. Assume you are a student in classes where these questions would be appropriate. Rank the questions from easiest to most challenging based on the character of the question.

   A. Which one of the following values approximates best to the volume of a sphere with radius 5m?

      a) $2000m^3$ b) $1000m^3$ c) $500m^3$ d) $250m^3$ e) $125m^3$

   B. How successful were recent income tax cuts in spurring economic growth?

   C. What is the capital of Maine?

   D. How would you restructure the school day to reflect children's developmental needs?

   E. Contrast the floor of the Atlantic Ocean with the shape of a bathtub.

   F. Which statements in the President's State of the Union address were based on facts and which were based on assumptions?

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2. Now think of the questions from the point of view of an instructor who assigns these questions as homework in a class of 100 students at different times during a semester.

   A. Which three questions would require the most time and effort to grade?

   B. Why?

Aligning Learning Goals & Measures of Learning Outcomes

Using Bloom's Taxonomy to Scaffold Learning

Over forty years ago, Benjamin Bloom and co-workers created a taxonomy of educational objectives that provides a useful structure for organizing learning exercises and assessment experiences (Bloom and others, 1956; Anderson and Sosniak, 1994; Anderson and Krathwohl, 2001). Bloom's taxonomy divided cognitive learning into six levels, from lower-level thinking skills such as memorization to higher order thinking that involves analysis, synthesis and/or evaluation of information. Each taxonomy level is described briefly below and examples of questions linked to each of level are discussed.

Bloom's Taxonomy	**Learning Skill**	**Question stems***
Knowledge	memorization and recall	What is . . . ? Who, what, when, where, how ...? Describe . . .
Comprehension	understanding	What would happen if . . . ?; What does . . . illustrate about . . .?; What is analogous to . . . ?
Application	using knowledge	How could . . . be used to . . . ? What is another example of . . . ?
Analysis	taking apart information	How does . . . affect . . . ? What are the differences (similarities) between . . . ? What causes . . . ? How does . . compare/contrast with . .?
Synthesis	reorganizing information	What is a possible solution for the problem of . . . ? How would you create/design a new . . ? How does . . . relate to what we learned before about . . . ?
Evaluation	making judgments	Why is . . . important? What is the best . . . , and why? Do you agree/disagree that . . . ?

* from King, A., 1995, Teaching of Psychology, v.22, p. 13-17.

References:

Anderson, L.W., and Krathwohl, D.R., 2001, A Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of educational objectives. Longman.

Anderson, L.W., and Sosniak, L.A., 1994, Bloom's Taxonomy: A forty-year retrospective. National Society for the Study of Education.

Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W.H., and Krathwohl, D.R., 1956, Taxonomy of educational objectives: Handbook 1: Cognitive domain. David McKay.

Summary of Bloom's Taxonomy

Knowledge

Answers to knowledge questions indicate if a student knows and can recall specific information. Examples of questions that assess knowledge are some types of multiple choice questions, true/false questions, definitions, matching questions, or lists. Questions that ask students to define, identify, list, or name are often "knowledge" questions.

Comprehension

Responses to comprehension questions report information or observations that don't simply repeat something presented in class. Students must possess some basic knowledge and/or conceptual understanding to correctly answer comprehension questions. Comprehension questions can fall into several categories and may require that students convert, summarize, classify, infer, compare, or explain information.

Application

Application often involves applying rules or principles to new situations, using known procedures to solve problems or demonstrating how to do something. Questions that ask students to solve a problem using a known equation or to select a procedure to complete a new task would be considered application questions.

Analysis

Answers to analysis questions may give directions, make commentaries, scrutinize data, explain how something works, or distinguish fact from opinion. Analysis requires that students break information into component parts to identify its organization. Students are expected to find links between data and interpretations and to discover which material is relevant to a task and which is extraneous. Questions that ask students to diagram, illustrate, outline or subdivide would be considered analysis questions. Simple questions that involve few items are more likely examples of comprehension, rather than analysis.

Synthesis

While analysis typically requires that students break information down into its constituent parts, synthesis combines a series of parts into a greater whole. Good answers to synthesis questions may predict the outcome for a particular event and may involve making generalizations and developing a "big picture" view of a phenomenon or feature. Questions that ask students to combine, compile, create, devise, plan, or organize are often considered synthesis questions. Questions may ask students to create multiple hypotheses to explain a phenomenon, to develop a plan to solve a problem or to devise a procedure to accomplish a task.

Evaluation

Responses to evaluation questions make judgments about facts, data, opinions or research results using evidence and scientific reasoning. Good answers require students to analyze and synthesize substantial amounts of information and clarify ideas. Evaluation questions might ask a student to appraise, criticize, justify, or support an idea or concept.

Bloom's Taxonomy Exercise

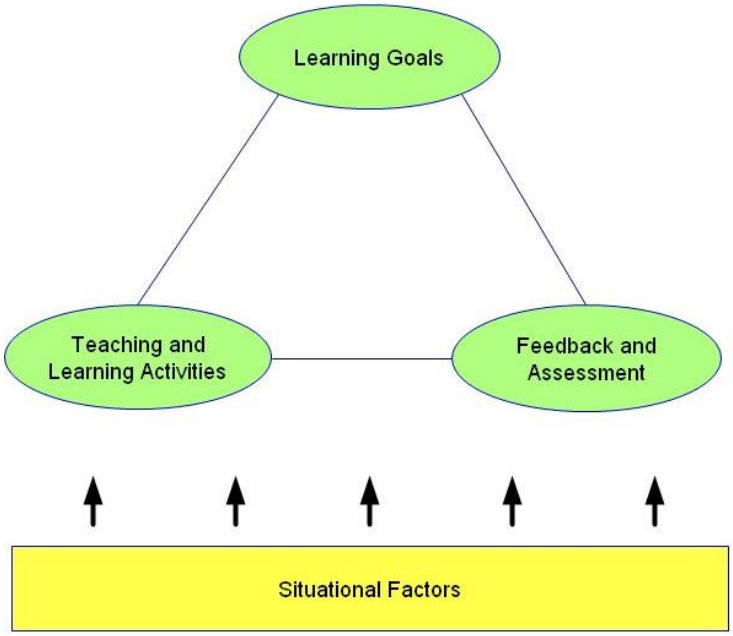
Think about the learning goals you might have for one of your lessons (lectures). What do you want your students to know and be able to do? Consider writing your learning goals starting with the phrase "Students will be able to . . . " (SWBAT). Make these goals explicit to students by posting them in your presentation or on the class website.

Then consider what assessment you could use to measure if students had achieved those goals. There may be several different assessments that could be delivered in class (formative) or on subsequent exams or home works (summative).

This presentation is designed to encourage you to think about different ways to conduct assessments in your course.

Review the examples of exercises used in general education introductory geoscience courses and rank them according to Bloom's Taxonomy.

Place each exercise into one of the six levels (knowledge, comprehension, application, analysis, synthesis, evaluation). Review the first few pages for descriptions of these levels. Some exercises may display multiple questions that can be ranked at different levels in the Taxonomy. Choose the highest level.



(Fink reference: http://www.designlearning.org/wp-content/uploads/2010/03/Self-Directed-Guide..2.pdf)

Complete the table below by circling the abbreviation of the appropriate taxonomy class.

Exercise	**Bloom's Taxonomy Level**
Sediment and Sedimentary Rock Quiz	K C Ap An S E
Venn Diagram A (Hurricanes vs. Tornadoes)	K C Ap An S E
Venn Diagram B (Coal vs. Oil resources)	K C Ap An S E
Life on Mars	K C Ap An S E
Groundwater Rubric (Groundwater Resources)	K C Ap An S E
Physical Weathering Concept Map	K C Ap An S E
Student Answer Interpretation (Atmosphere)	K C Ap An S E
Relative Time Diagram	K C Ap An S E
Concept Map	K C Ap An S E
Concept Sketches	K C Ap An S E
Seismic Stratigraphy Exercise	K C Ap An S E

Sediment and Sedimentary Rock Quiz

a) The dominant transport medium in eolian environments is_____.

b) A channel avulsion is
when_____.

c) What is the percentage of feldspar in a lithic wacke?

d) What percentage of a rock must be larger than 2mm, rounded clasts in order for it to be a conglomerate?

e) Define Oligomictic.

f) Are shoreface sediments finer towards land or the sea?

g) The continental margin marine environment is divided into three sub-environments, what are they (assume you are on a passive margin)?

h) Define the CCD.

i) List four characteristics of alluvial fans.

j) List four fluvial channel shapes.

k) What types of environments produce lithic sandstones?

l) Compositionally mature clastic rocks contain lots of_____.

m) Texturally immature clastic rocks are_____.

n) What is the maximum amount of clay that can be in a siltstone?

Open-ended Question: Life on Earth and Mars

Which of the two scenarios described below would be most likely to support life on Earth?

1. Earth is the same size as present but has the orbit of Mars

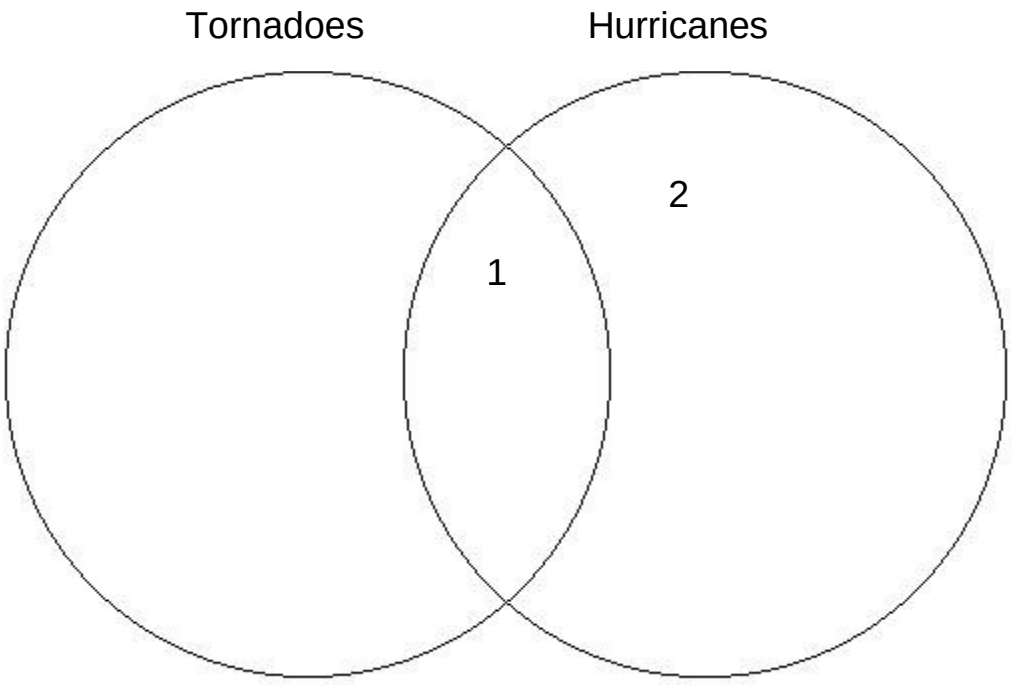
2. Earth has the same orbit as present but is the size of Mars

Explain the reasons you used to support this interpretation in the space below.

Venn Diagram A

Tornadoes vs. Hurricanes

List the features that are unique to either group or that they share on the back of this page. Provide a brief but clear description of each feature (see examples). Two features are included as examples. Write the appropriate number in the corresponding locations on the Venn diagram below. (One example has been included.)



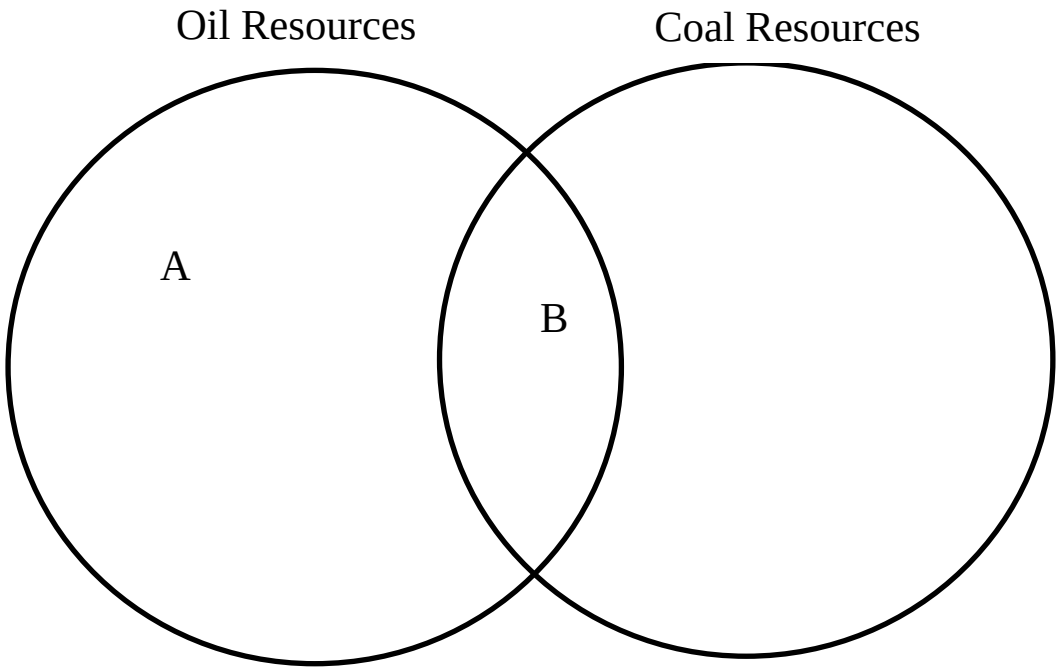
Features

1. Low pressure systems
2. Form over oceans
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.

Venn Diagram B

Compare Oil and Coal Resources

1. Use the Venn diagram to compare and contrast the similarities and differences between the characteristics of oil and coal resources.



A. No current production in North Carolina
B. Examples of fossil fuels
C. Main source is dead organisms
D. Produce greenhouse gases when consumed
E. Need sufficient heat and burial during formation
F. Produced from kerogen
G. Non-renewable
H. Formed from vegetation
I. Formed from marine organisms
J. 25% of global reserves in US
K. Produced by mining
L. Migrate upward after formation
M. Texas produces more than any other US state
N. Used to produce gasoline
O. Most used to generate electricity
P. Contain carbon
Q. Middle East has most of world's reserves
R. Four varieties based on increasing carbon content (e.g., peat, anthracite)
S. From tar sands and oil shales
T. US uses 25% of global production
U. Typical power plant fuel
V. Most is imported from other nations
W. Forms over very long time intervals (100,000s+ years.

Groundwater Rubric

Groundwater Resources

You are part of a team that is given an assignment to help locate a new well field that will supply your town with water. In examining the potential site locations you recognize that there are several different factors that will influence groundwater availability and no site is perfect.

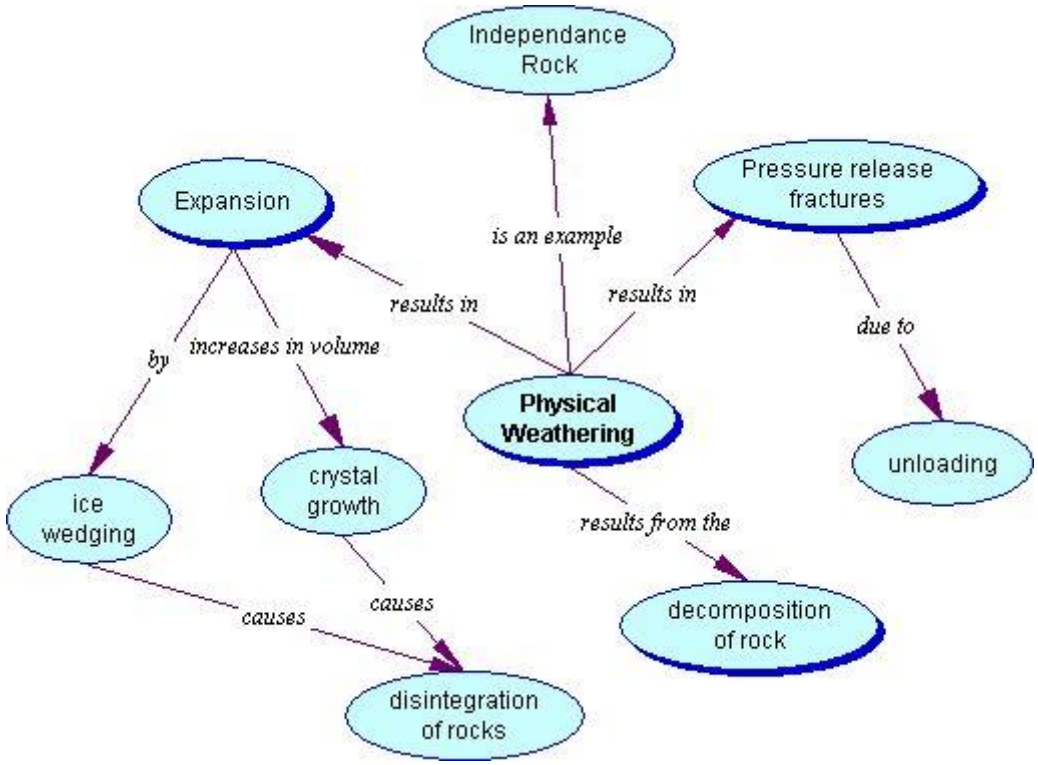
You are asked to create a **scoring rubric** to evaluate at least five factors that will influence the availability of groundwater. The location that scores the highest using the scoring rubric will be selected for the well field. One factor is included as an example in the table below; identify four more.

You are given the opportunity to identify which is the most important factor and double its score. Which factor would your choose?

Factors	**Good (3)**	**Moderate (2)**	**Poor (1)**
Depth to water table	Shallow	Intermediate	Deep

Physical Weathering Concept Map

Review the concept map presented below that describes the basic characteristics of physical weathering. Score the concept map using the **grading rubric** and redraw the diagram making whatever changes you believe are appropriate to earn a "4" on the grading scale.



Grading Rubric

0 The concept map does not contain any information about physical weathering.

1 The concept map contains some relevant terms but several key terms are omitted and many linking phrases are either absent or inaccurate.

2 The concept map contains most relevant terms but they are poorly organized and some linking phrases are absent or incorrect.

3 The concept map contains most relevant terms but one or two key term(s) may be absent. The diagram is reasonably well organized, and almost all linking phrases are appropriate.

4 The concept map contains all relevant terms in a well organized display that has appropriate linking phrases for each pair of terms.

Student Answer Interpretation

Atmospheric Pressure and Condensation

An instructor asked her class to summarize some information from the section of a chapter on atmospheric pressure. Four students submitted the statements below as part of their answers. She returned the statements and told the students that they could correct them for full credit. Identify what is wrong with each statement and describe how you would fix these answers to earn full credit.

A. The temperature of a rising parcel of air decreases by the normal lapse rate.

B. The percentage of oxygen in the atmosphere decreases with altitude.

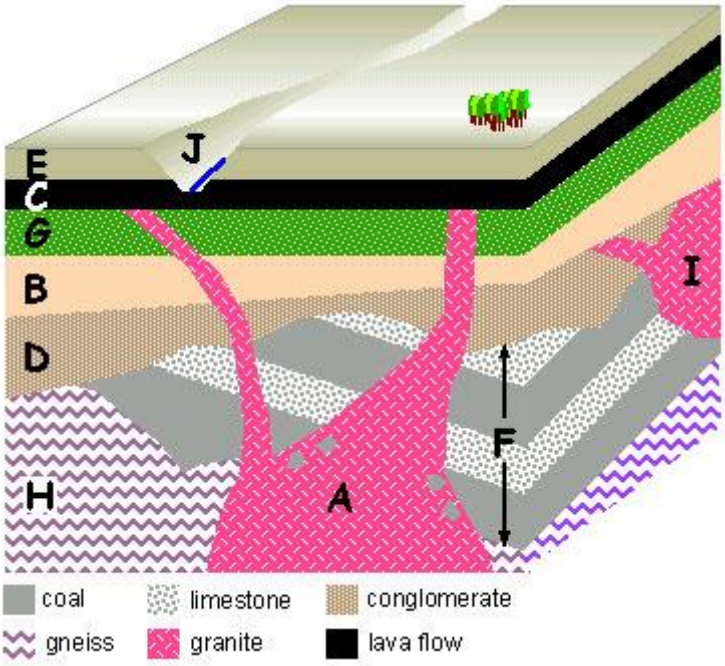
C. When it rains you have to use the wet adiabatic lapse rate to figure out temperatures at higher elevations.

D. The dry adiabatic lapse rate is higher than the wet adiabatic lapse rate so air temperatures should be higher in dry air (before condensation occurs) than in wet air (after condensation occurs).

Relative Time Diagram Interpretation

Complete the exercise by using the principles of superposition, original horizontality, and cross-cutting relationships to determine the order of events for the idealized location shown in the figure.

Place the rock units in their order of formation, oldest to youngest.



Oldest

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

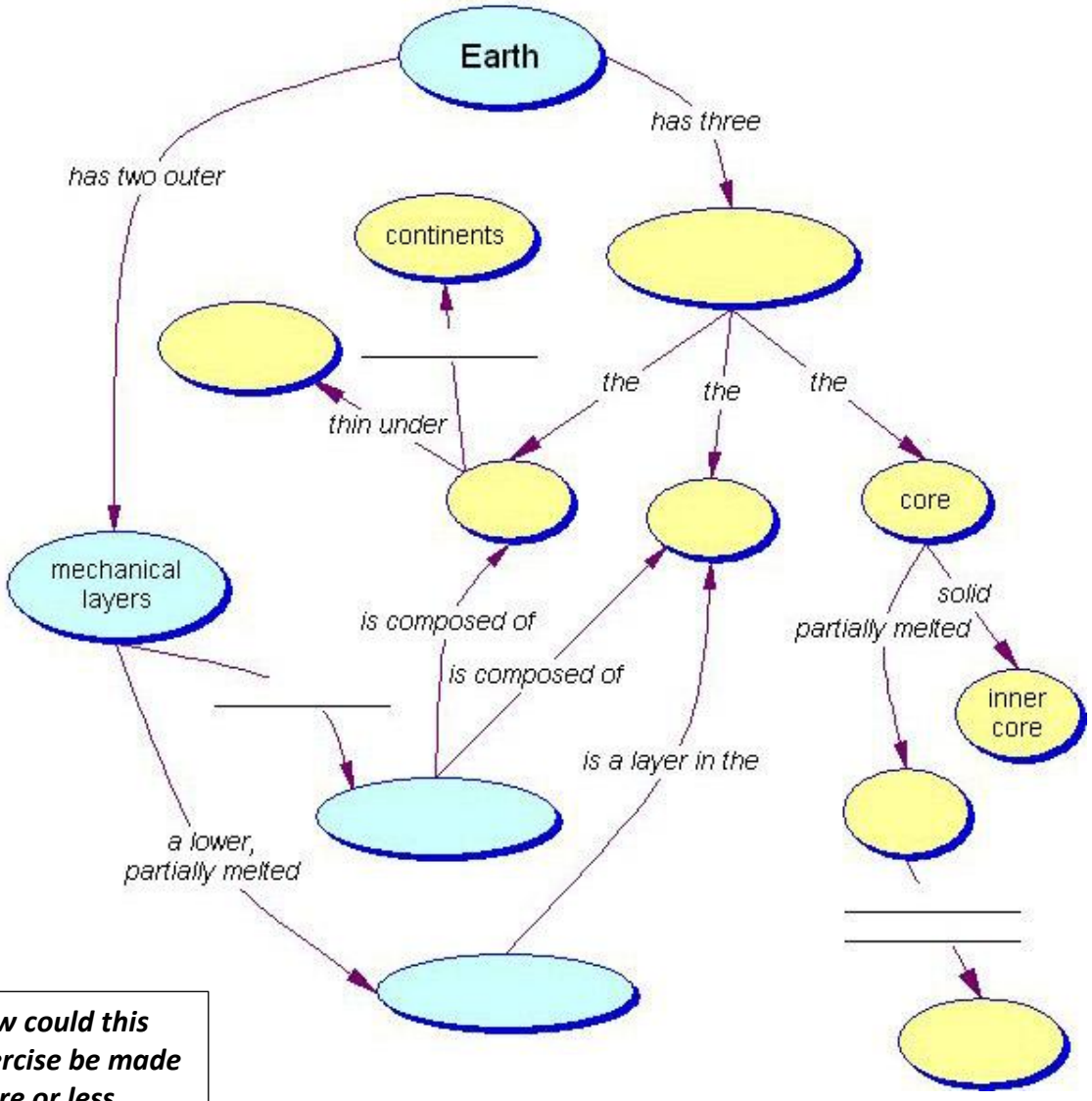
Youngest

Concept Map

Earth's Layers

Complete the concept map below by correctly adding some of the terms provided to the appropriate blank locations either as key terms or connecting phrases/terms. Some necessary terms are not included in the list; others may not be applicable to this diagram.

1. *compositional layers*
2. *crust*
3. *one of three*
4. *oceans*
5. *is the source of Earth's*
6. *an upper rigid*
7. *characteristic of terrestrial planets*



How could this exercise be made more or less challenging?

Concept Sketches (Suki Smaglik)

Students are given a list of required concept sketches at the beginning of each unit (3-5 chapters) and are expected to know the information well by exam time. For the exam, I choose 2 or 3 questions and make one PowerPoint slide. Students are given a blank sheet of paper (usually colored so that they can't bring in pre-made ones) and are asked to construct one sketch on each side. See below for examples of questions used in the last two exams of this semester.

Sketch, label and describe how flow velocity and channel profile vary in a meandering river, and what features form along different parts of bends. In addition, use a series of sketches to describe how meanders in a river form and move.

Sketch, label and describe what the water table represents. In addition discuss the controls on water flow through rocks, including porosity and permeability, providing examples of materials with high and low values of each. In addition, describe some of the problems associated with groundwater pumping.

Sketch, label and describe the greenhouse effect. Summarize the major factors, both natural and anthropogenic, that influence atmospheric temperature. Describe the evidence for increased greenhouse gas concentrations in the atmosphere, and for correspondence between increases in these gases and increases in temperature.

Seismic Stratigraphy Exercise

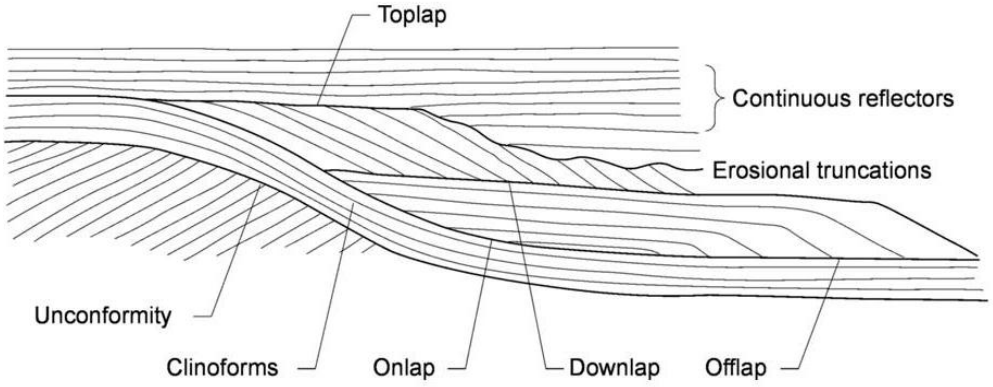
Purpose: There are times when even drilling a borehole is either impossible (e.g. deep submarine strata) or impractical (you need to cover a very large area at a relatively low cost). In those (and, of course, other) instances, seismic data can be extremely useful for interpreting subsurface geology. Seismic stratigraphy is the study of seismic data for the purpose of interpreting sedimentary strata.

Reflection surfaces in the subsurface may be parallel (uniform sedimentation on a uniformly subsiding substrate), divergent (differing sedimentation rates or subsidence rates/accommodation space), prograding (gently dipping, slope parallel surfaces known as **clinoforms** as sediment builds laterally), or chaotic (may represent deformation of sediment or primarily unordered sediment).

Because divergent reflectors can represent changes in either sediment supply or accommodation space, they can provide information about basin type and geometry or changes in sedimentary environment. Those changes are recorded in particular patterns of reflectors.

Reflector patterns and relationships on seismic profiles

Gary Nichols, Sedimentology and Stratigraphy



Inclined reflectors that terminate at a horizontal upper surface represent sediment prograding horizontally into a basin (vs the vertical accumulation associated with clinoforms) and this pattern is known as **toplap**.

Horizontal or gently dipping reflectors that increase in extent with elevation and terminate against a steeply inclined surface represent depositional infilling of a basin or basin subsidence and this pattern is known as **onlap**.

The opposite of onlap is known as **downlap.** In downlap, steeply dipping reflectors terminate downdip against horizontal or more gently inclined surfaces. Downlap may represent the termination of dipping surfaces building into a basin as sediment accumulates (e.g. toplap + aggradation) as along the front of a prograding delta. The pattern of prograding surfaces building out and up in a basin are, themselves, referred to as **offlap**.

In addition to the patterns and arrangement of reflectors, the continuity and type of reflector also gives some indication of subsurface lithology. Finer sediments deposited in quiet water tend to give good, continuous reflections. Coarser sediments (sands and gravels) that do not have as well-defined bedding planes tend to produce continuous but less cohesive, more chaotic reflections. Basement rock tends not to produce "bright", regular reflections.

Deliverables: Review the seismic reflection line below and complete the tasks described.

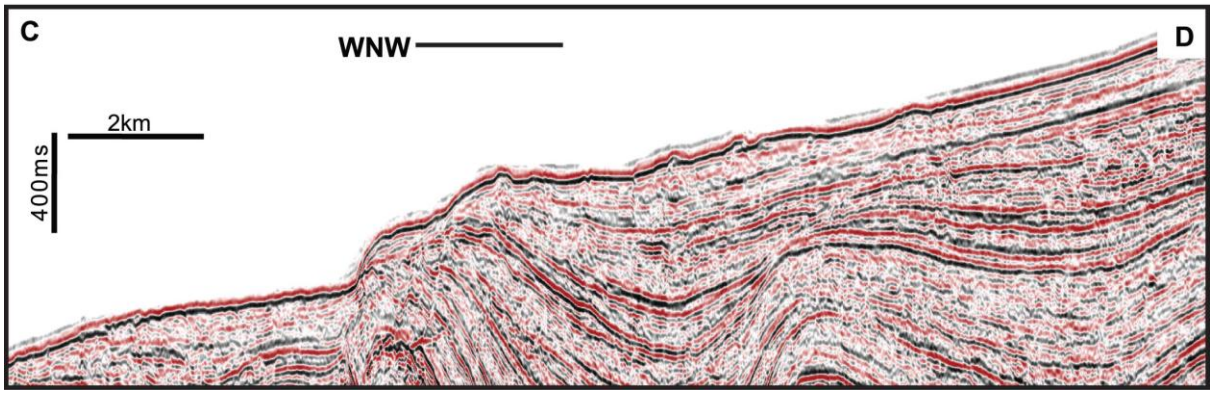
1. Use colored pencils, pens, highlighters etc. to interpret the subsurface stratigraphy as in the example.

    a) Be sure to **clearly highlight the break** between the basin "bedrock" and the deposited sediments.

    b) **Highlight enough reflectors** to clearly demonstrate your interpretation and the stratigraphic relationships contained within the section.

    c) **Identify and label** as many of the possible reflector truncations or arrangements (e.g. downlap, clinoforms etc.) as you can.

    d) **Identify and label** possible lithologies/seismic facies as in the example (e.g. sands vs quiet water muds).



Open-ended questions and rubrics*

WHAT DO WE MEAN BY A "RUBRIC"?

A rubric or scoring protocol is used for the following:

1. *Specifies criteria and a measurement scale for different levels of proficiency* (Gall et al., 1996, p. 267).
2. Purpose is to identify salient points & weight of responses (Tanner, 2001).
3. *Indicate what the scorer should look for in the response...most relevant...to be ignored...determine how much emphasis the various elements of the response should receive* (Tanner, 2001, p. 144).

WHY/HOW/WHERE/WHEN DO WE USE RUBRICS?

We use rubrics in performance assessment/authentic assessment/alternative assessments:

1. *Represent complex, complete, real-life tasks* (Gall et al., 1996, pp. 266-267).
2. Performance and/or product assessed (Tanner, 2001).
3. *Task to demonstrate...level of competence or knowledge by creating a product or a response* (Eggen & Kauchak, 1999, pp. 595-596).
4. *Authentic assessment...no standard definition...philosophy and practical data collection techniques* (Travers et al., 1993).
5. To demonstrate and evaluate skills (Travers et al., 1993).

STEPS FOR PLANNING AUTHENTIC ASSESSMENT

1. Know the characteristics of your students: levels of cognitive, physical, and social-moral development.
2. Define performance to be assessed: process or product or both.
3. Construct performance test: what students will actually do.
4. Design scoring rubric: range of performance, scoring criteria, cut scores.
5. Consider sharing rubric with students during assignment of task.

REFERENCES

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Travers, J.F., Elliott, S.N., & Kratochwill, T.R. (1993). Educational psychology: Effective teaching, effective learning. Madison, WI: Brown & Benchmark

**From UA CCI Workshop with facilitators Janet Bean, Lynne Hammann, Richard Stratton, David McConnell.*

Advice for Developing Rubrics*

1. Establish Criteria

- What are your learning goals for assignment? It may sound obvious, but we should grade what we want students to learn.
- What are the conventions of your discipline? The genre of this assignment? Don't let these features be invisible—what may seem obvious to you may not be obvious to students. Communicate your expectations about discourse conventions.
- Focus on three to five main criteria. Or four to six. Or five to fifteen. It depends on who you ask. But I *can* tell you that a more detailed rubric is not necessarily a more effective rubric.
- Each criterion should focus on a different skill, characteristic, or outcome.

2. Determine How You Will Score

- Analytic/Primary Trait: You rate students' success at achieving each criterion. For example, you might have five criteria and a scoring range of 1-4 for a total possible point value of 20.
- Holistic: You rate students' success globally, using your criteria as a guideline.

3. Write the Scoring Levels

- For analytic/primary trait, you'll write scoring levels for each criteria. For holistic, you'll write global descriptions of each level (An "A" essay does the following.... A "B" essay does...).
- Some helpful words that signify levels:

  Needs Improvement...Satisfactory...Good...Exemplary
  Beginning...Developing...Accomplished...Exemplary
  Needs work...Good...Excellent
  Novice...Apprentice...Proficient...Distinguished

  Depth...Breadth...Quality...Scope... Complexity...Degrees...Accuracy
  Presence to absence
  Complete to incomplete
  Many to some to none
  Major to minor
  Consistent to inconsistent
  Frequency: always to generally to sometimes to rarely

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