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. Students must possess some basic knowledge of the subject 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.

Synthesis

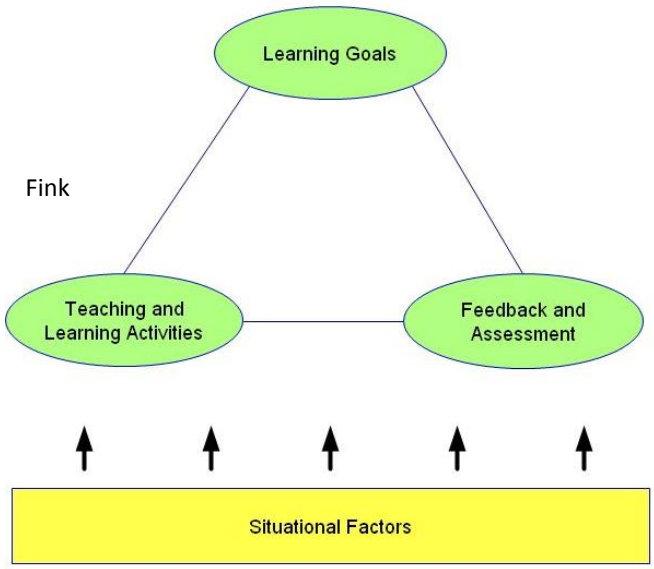
While analysis typically requires that students break information down into its constituent parts, synthesis combines a series of parts into a greater whole. Good answers to synthesis questions may predict the outcome for a particular event and may involve making generalizations and developing a "big 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 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 two 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.

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

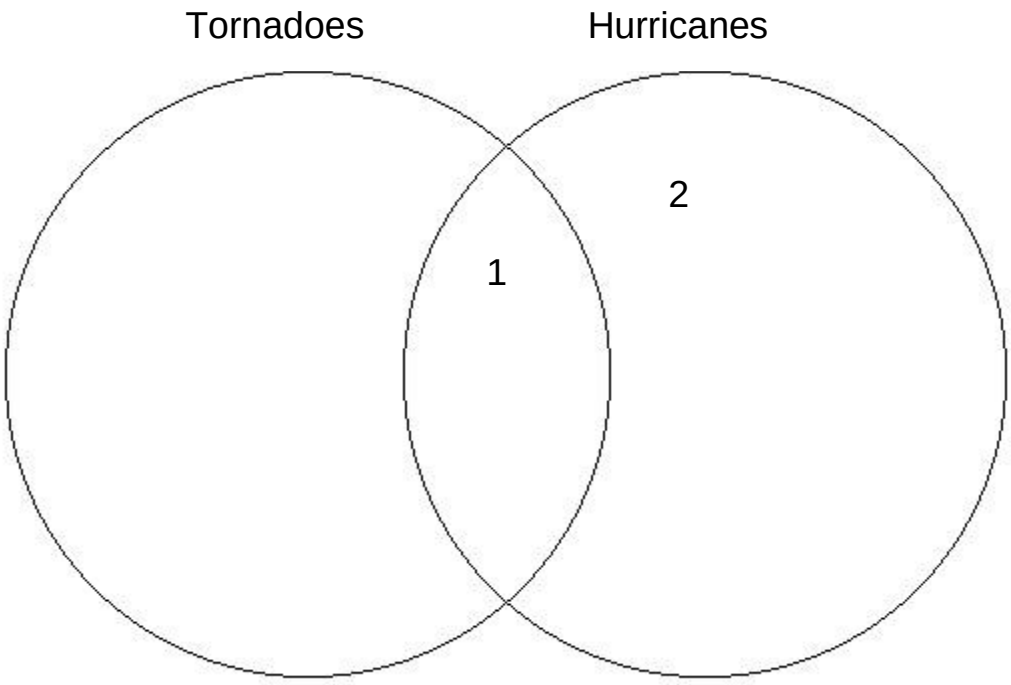
Exercise	**Bloom's Taxonomy Level**					
Venn Diagram A (Hurricanes vs. Tornadoes)	K	C	Ap	An	S	E
Venn Diagram B (Coal vs. Oil resources)	K	C	Ap	An	S	E
Evaluation Rubric (Groundwater Resources)	K	C	Ap	An	S	E
Student Answer Analysis A (Global Warming)	K	C	Ap	An	S	E
Student Answer Analysis B (Atmosphere)	K	C	Ap	An	S	E
Concept Map	K	C	Ap	An	S	E
Concept Sketches	K	C	Ap	An	S	E
Online Discussions	K	C	Ap	An	S	E

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

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.)



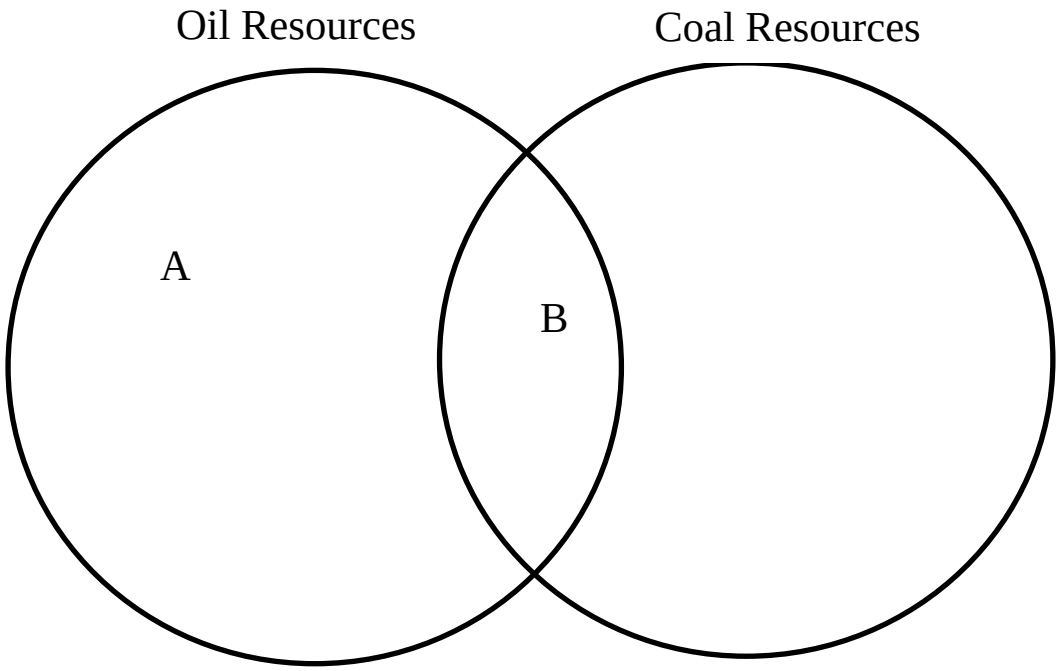
Features

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.

Evaluation 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

Student Answer Analysis

Global Warming Definitions

Review the student definitions of global warming below and rank them from best to worst (best = 1, worst = 7). In the space below identify the criteria you used to rank the definitions. (For example, why is the 1st ranked definition better than the 7th ranked definition?)

___ Global warming occurs when the temperature of the environment reaches a certain level. It results from more sunlight reaching Earth as the atmosphere decays because of pollution. Breaks in the atmosphere allow extra heat to reach Earth.

___ Global warming is the gradual warming of Earth due to the greenhouse effect.

___ Global warming is a gradual, long-term increase in the temperature of Earth due to an increase in the concentration of trace atmospheric gases such as carbon dioxide that trap heat from Earth's surface.

___ Global warming occurs when the temperature of the Earth slowly increases because a layer of chemicals in the atmosphere traps more heat than normal.

___ Global warming is the warming of climate over many years as a result of natural phenomena such as volcanic eruptions, El Nino, that trap heat close to Earth's surface.

___ Global warming is the result of the ozone layer in the atmosphere becoming thinner due to certain chemicals we use. This causes more solar radiation to reach Earth's surface, leading to higher average temperatures.

___ Global warming is due to Earth's position in space relative to the Sun. Solar radiation strikes the Earth more directly during times of global warming as a result of changes in Earth's orbit.

Student Answer Analysis

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.

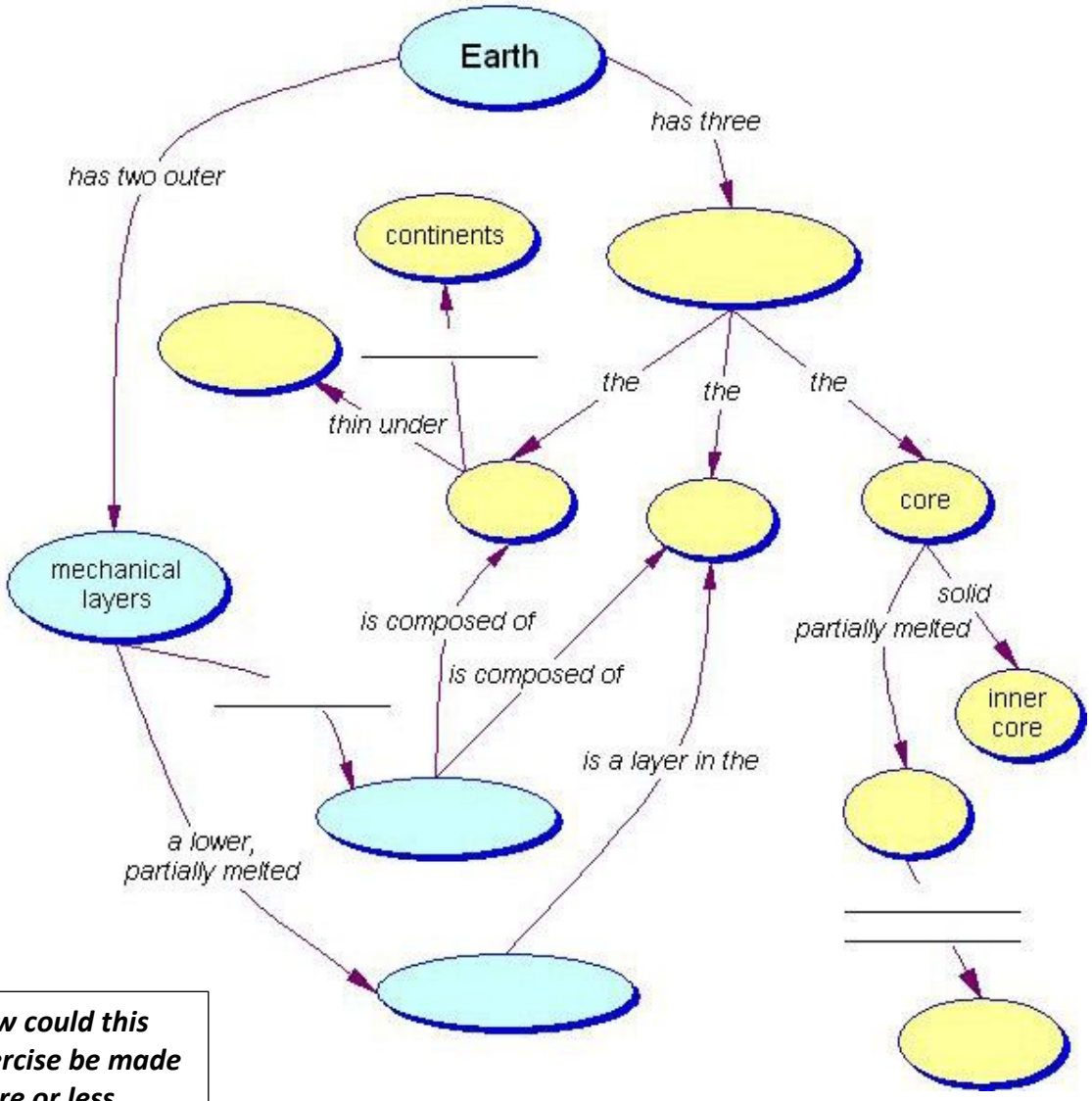
D. The dry adiabatic lapse rate is higher than the wet adiabatic lapse rate so air temperatures should be higher in dry air (before condensation occurs) than in wet air (after condensation occurs).

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)

I use Concept Sketches two ways.

1. As a homework assignment that students complete in their journal. I have the students discuss their homework with each other in class in order to improve their answers for the exams.
2. As an assessment (a.k.a. exam).

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. They 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. I use the same questions in my Physical Geology course.

> Sketch and describe the role that gravity plays in slope stability, including the concept of the angle of repose and its landscape expressions. What are some factors that control slope stability, and events that trigger slope failure?
>
> OR
>
> Describe how earthquakes can cause destruction both during and after the main earthquake. Sketch and label a few examples. Discuss some ways to limit our risk and reduce personal injury during a quake.
>
> 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.

Online Discussions (Sheila Roberts)

Learning outcomes

1. Utilize geological concepts to evaluate relevant societal issues
2. Find and evaluate relevant geological information
3. Communicate clearly, in writing, to an identified audience

This assignment is designed to get students to see the application of geology to local problems, such as hydrologic fracturing or coastal erosion along the Lake Erie shoreline. Students often have strong opinions about these issues, but often do not have a clear understanding of the science supporting or refuting their position. In introductory courses, students are given a list of articles to read about the topic. In upper-level courses, students must find information to formulate and support their position.

The rubric used to assess this activity is included below. Frequency of posts is weighted heavily because students often wait until just before the assignment is due to contribute to the discussion, making it virtually impossible for others to respond to their comments.

Discussion Board Grading Rubric (Sheila Roberts)

Criteria	Unacceptable 0 Points	Acceptable 1 Point	Good 2 Points	Excellent 3 Points
Frequency **Weight: 3**	Participates not at all.	Participates 1-2 times on the same day. Postings may not be made in time for others to read and respond.	Participates 3-4 times but postings not distributed throughout week. Postings are made in time for others to read and respond.	Participates 4-5 times throughout the week. Postings are made in time for others to read and respond.
Initial Assignment Posting **Weight: 1**	Posts no assignment.	Posts adequate assignment with superficial thought and preparation; doesn't address all aspects of the task.	Posts well developed assignment that addresses all aspects of the task; lacks full development of concepts.	Posts well developed assignment that fully addresses and develops all aspects of the task.
Follow-Up Postings **Weight: 1**	Posts no follow-up responses to others.	Posts shallow contribution to discussion (e.g., agrees or disagrees); does not enrich discussion.	Elaborates on an existing posting with further comment or observation.	Demonstrates analysis of others' posts; extends meaningful discussion by building on previous posts.
Content Contribution **Weight: 3**	Posts information that is off-topic, incorrect, and/or irrelevant to discussion.	Repeats but does not add substantive information to the discussion.	Posts information that is factually correct; lacks full development of concept or thought.	Posts factually correct, reflective and substantive contribution; advances discussion.
Clarity & Mechanics **Weight: 1**	Posts long, unorganized and/or rude content that may contain multiple errors and/or may be inappropriate.	Communicates in friendly, courteous and helpful manner with some errors in clarity and/or mechanics.	Contributes valuable information to discussion with minor clarity and/or mechanics errors.	Contributes to discussion with clear, concise comments formatted in an easy to read style that is free of grammatical and/or spelling errors.
General **Weight: 1**	Posts long, unorganized and/or rude content.	Communicates in friendly, courteous and helpful manner.	Contributes valuable information to discussion.	Contributes to discussion with clear, concise comments formatted in an easy to read style.