Learning Outcomes for my Upper Level Courses:

In a recent letter from the Dean, College of Liberal Arts and Sciences, faculty were told:

"Almost two years ago the AU Student Learning Assessment Committee reminded us that all of our syllabi need to have learning outcomes stated on them and I have reminded chairs and faculty of this from time to time. At our January 2011 Retreat lead by the General Education Taskforce, colleagues on GET walked us through what a learning outcome is and how to write one. I have attached their handout on learning outcomes from that meeting, which is also on our CLAS Blackboard site. [*see below*] Please remember that our accreditation body, the Middle States Commission on Higher Education, also reminded us in its last review that we need to state our learning outcomes more clearly. With the next Middle States review already on the horizon, we should be at a point where learning outcomes are consistently and clearly stated on each syllabus within the College."

HOW TO WRITE STUDENT LEARNING OUTCOMES

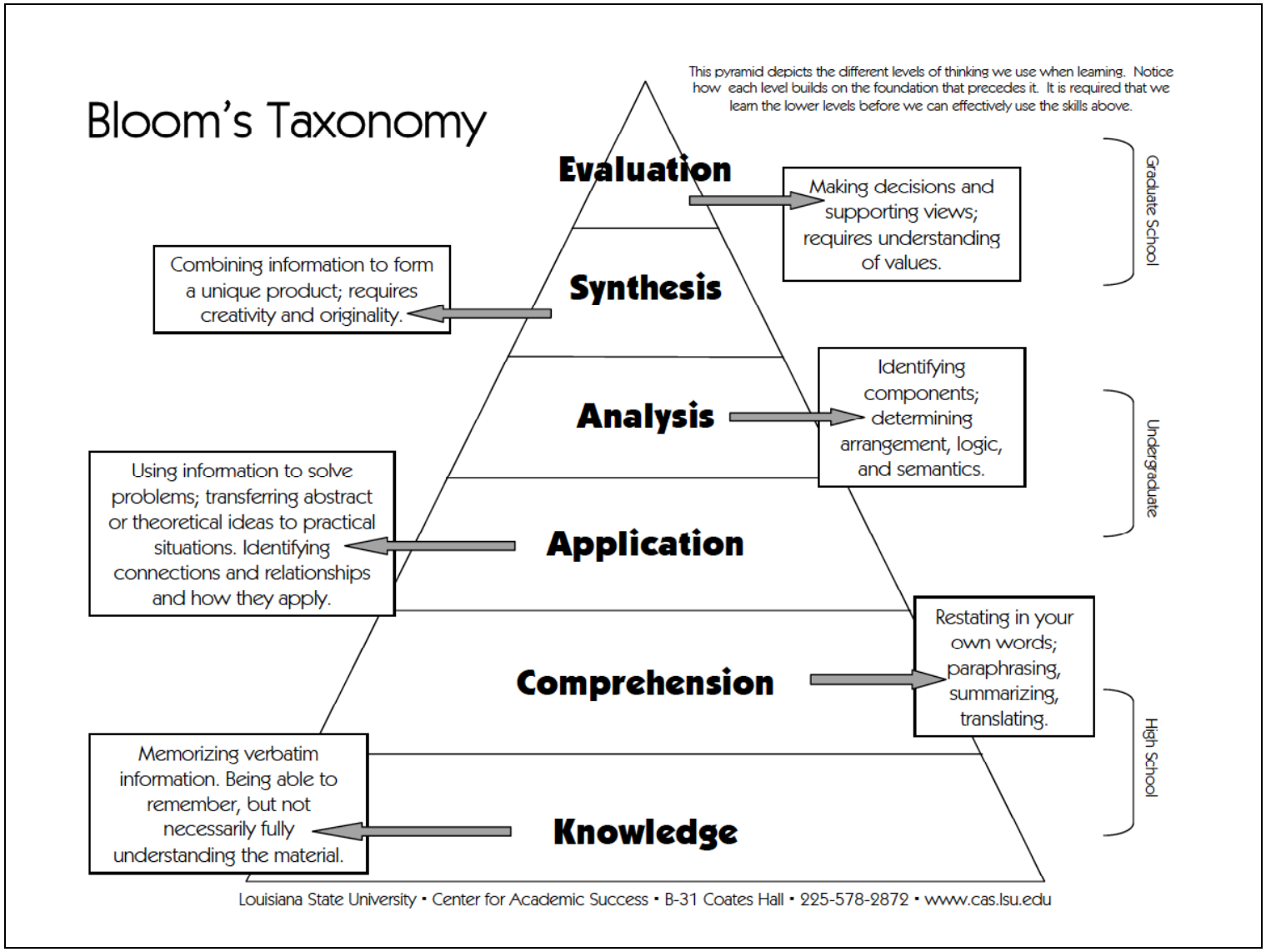
Action Verb List – Suggested Verbs to Use in Each Level of Thinking Skills

Below are terms (verbs) that can be used when creating student learning outcomes for a course or degree program.

Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Count	Associate	Add	Analyze	Categorize	Appraise
Define	Compute	Apply	Arrange	Combine	Assess
Describe	Convert	Calculate	Breakdown	Compile	Compare
Draw	Defend	Change	Combine	Compose	Conclude
Identify	Discuss	Classify	Design	Create	Contrast
Labels	Distinguish	Complete	Detect	Drive	Criticize
List	Estimate	Compute	Develop	Design	Critique
Match	Explain	Demonstrate	Diagram	Devise	Determine
Name	Extend	Discover	Differentiate	Explain	Grade
Outlines	Extrapolate	Divide	Discriminate	Generate	Interpret
Point	Generalize	Examine	Illustrate	Group	Judge
Quote	Give examples	Graph	Infer	Integrate	Justify
Read	Infer	Interpolate	Outline	Modify	Measure
Recall	Paraphrase	Manipulate	Point out	Order	Rank
Recite	Predict	Modify	Relate	Organize	Rate
Recognize	Rewrite	Operate	Select	Plan	Support
Record	Summarize	Prepare	Separate	Prescribe	Test
Repeat		Produce	Subdivide	Propose	
Reproduces		Show	Utilize	Rearrange	
Selects		Solve		Reconstruct	
State		Subtract		Related	
Write		Translate		Reorganize	
		Use		Revise	
				Rewrite	
				Summarize	
				Transform	
				Specify	

It may be useful to explore the likely origins of this table. In 1956 Bloom suggested the six levels seen across the top, and these have generally come to be known as "Bloom's Taxonomy." In the 1990's it became fashionable to restate nouns as verbs and a number of papers were written extolling the virtues of using "Identitfy" rather than "Identification" to refer to what is effectively the same skill.

Bloom's Taxonomy is often referred to as a "Pyramid" and represented by a triangle, bringing into question the ability of those doing so to identify some basic geometric shapes. But anyway, here is one from Louisiana State University:



Of particular interest is that the first two columns on the table, "Knowledge" and "Comprehension" represent verbs which should be used for Learning Outcomes in High School. Upper level college courses should be working at the levels of "Application," "Analysis," and "Synthesis."

My upper level courses use Graded Learning Opportunities to assess learning outcomes. These Graded Learning Opportunities will often require students to solve problems or answer essay questions. Here are some examples, lifted from some of those Graded Learning Opportunities:

From GEOL 301, Structural Geology:

1. The roof on the front side of a house has an attitude of N 30 E, 20 E. There is a flagpole in front of the middle of the house. Assuming the sun is directly south of the house at noon, what is the plunge and bearing of the shadow cast by the flagpole on the roof at noon? Show your work, and try to draw a sketch of this situation.

This requires a student to **draw** a sketch, or **diagram** the situation, **develop** a strategy to **solve** the problem, which will probably entail **separating** the problem into parts, **operating** on the data presented using the correct trig function (**recalled** from memory) and **computing** the results.

From GEOL 307, Stratigraphy and Sedimentation

2. Over the last 600 million years, seawater chemistry has varied as rates of sea floor spreading have changed. Show why this occurs, how this changes the minerals produced by calcium carbonate secreting organisms, and what can be observed in samples obtained today to figure out when these changes occurred in the geologic past.

To answer this question the student must first **recall** how seawater chemistry changed, **identifying** Ca and Mg as the ions which vary. Next, she needs to **explain** that increasing rates of sea floor spreading will result in more hot ocean crust, and **relate** that to an increase in hydrothermal flux. She needs to **point out** that water moving through this system will be enriched in Ca and depleted in Mg, **concluding** that an increase in sea floor spreading should result in a lower Mg/Ca ratio. Having **demonstrated** this, she should go on to **discuss** the formation of calcite, aragonite and high magnesium calcite. She should **recognize** that Mg ions interfere with normal calcite formation, and **infer** that a lower Mg/Ca ratio favors calcite crystallization. Finally, she should **complete** her answer by **stating** that aragonite is not stable over geologic time, and **converts** to calcite. She would **describe** how fossils from the geologic past could be **examined** to see if recrystallization had occurred. If so, she could **infer** the initial formation of aragonite, and hence a high Mg/Ca ratio. If not, she would conclude that there had been a lower Mg/Ca ratio.

From GEOL 340, Mineralogy and Petrology

3. In the situation shown to the right, a ray of light comes into a sample at an angle of 45° and leaves the sample at an angle of 19° from the normal to the interface. Assume the index of refraction of air is 1.00. (16 points)

a. What is the index of refraction of the sample?

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b. What is the greatest angle (from the normal to the interface) at which a ray of light can leave the sample?

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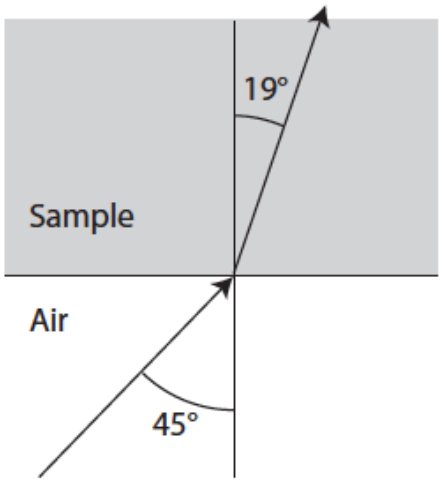

There are at least two approaches to **solving** this problem: The student could **recognize** that it is a simple application of Snell's Law, (without needing to know its name) or the student could effectively derive Snell's Law. In either case it would be necessary to **examine** the parameters, **breakdown** the problem into its constituent parts, **utilize** the correct trig function (**recalled** from memory or derived by **drawing** the proper geometry) to set up the equations correctly. **Calculating** a result by **dividing** sin 19 by sin 45, **identifying** this as being **related** to the index of refraction, and then **computing** the answer to part b by **using** the inverse sine of the quotient obtained earlier.

From GEOL 408, Tectonics:

4. Describe the technique of, and results obtained from, the deep seismic profiling (COCORP and others) of the continental crust. What do you consider to be the most significant conclusions to be drawn from this work, and why do you think so?

The student will have to **describe** this technique, **recalling** things she read, while **reproducing** the basic points and **summarizing** the big picture. In **discussing** the results obtained, she will need to **plan** and **organize** her answer, **grouping** together similar scenarios and **combining** them in order to **generalize** and **point out** those which she **judges** to be most significant. In **defending** her answer, she may need to **rank** the results, **rating** or **measuring** them **utilizing** some metric which she has **devised**.

From GEOL 414, Geophysics:

5. Assume a flat Earth. The boundary between Plate A and Plate B is a spreading center, with a North-South bearing, which is spreading perpendicular to its trend, at a rate of 4 cm/yr. The boundary between Plate A and Plate C is a spreading center, with a N 30 E bearing, which is spreading perpendicular to its trend, at a rate of 6 cm/yr.

a. If the boundary between Plate B and Plate C is a spreading center which is also spreading perpendicular to its trend, what is its trend?

b. What is the spreading rate of this spreading center?

c. Discuss the stability of the triple junction represented by this scenario.

This problem requires a student to **analyze** the problem, almost certainly by **drawing** a **diagram** with which she can **illustrate** the relevant vectors. Then the student needs to **develop** a strategy to **solve** the problem by first **relating** the vectors to each other, and then **computing** intermediate results. The process can be **completed** by **utilizing** the correct trig functions (**recalled** from memory). With these results in hand, the student can then **discuss** the stability of the triple junction **reproducing** what she has **read**, **rewriting** or **paraphrasing** as necessary.

For what it's worth, I have used questions of this sort for the last 41 years, advising students in my syllabi that questions "...will try to probe your understanding and comprehension of the material." It is not at all clear to me that using verbs from an approved list improves matters much, but I am happy to play along.