Tune up Your Teaching

Chuck Downing, Ph.D.

Introduction Most teachers today pay lip service at least to the idea that students need to think conceptually. Many would agree that, in our information society, conceptual understanding is more important than factual knowledge. Toward this end, many teachers try to implement conceptual assessment strategies in their classes. Frequently, the result of this implementation attempt is frustration-student answers fail to exhibit either depth of understanding or the ability to relate one topic to another, or both. Comments like, "I can't believe how much my students did not learn," or "My students can't handle conceptual assessments," abound in offices and faculty lounges. (Actual comments are likely to be much more colorful than these sterilized samples.)

Who's to blame? The blame for such inadequacies usually falls on the student. While much blame legitimately belongs with students, not all blame rests with them. Teachers must shoulder some blame for the lack of adequate student answers to conceptual prompts. Part of the blame lies in the prompts teachers provide students. .

> Many students and teachers alike have lamented that the format of problems in the classroom (particularly in math and science) bears little resemblance to the way problems look in real life. In fact, one of the most important practical thinking skills one can acquire is knowing how to identify a problem. [We need to] frame tasks so that students use skills similar to those needed for the ill-defined problems they will encounter in real life. Tasks developed [in this way] are sufficiently defined as to be solvable, but do not state explicitly which variable or aspect of the problem will constitute or enable a solution (Potts, 1994, 1)

So, there is a need to change our questioning if students are going to change their answers. How do we go about this task?

> To modify process [emphasis mine], activities must be restructured to be more intellectually demanding… [A]ctivities should be used in ways that encourage self-directed learning… Every teacher should know a variety of ways to stimulate and encourage higher level thinking skills. Group interaction and simulations… are a few of the methods for managing class activities that support process modification (Berger, 1991, 1).

Now wait a minute, I try to make my course intellectually demanding. But this sounds like theory to me.

What do I do? Look at the map in Figure 1. Without any contextual basis for the question, write a factual question about the map. Then write a conceptual question about the map. Don't continue reading until you have your two questions written.

Figure 1. Map of the World.

Now check you questions. Chances are good that your factual question exhibits many, or most, of the following characteristics. Your factual question:

- is specific
- has a right answer. (Probably one right answer.)
- is easily graded.
- requires recall or recognition skills

Sample factual questions are:

1. Name the body of water located between America and Europe.
2. What continent lies south of the United States?
3. What mountain range is part of the border between India and Siberia?

Equally likely is the chance that your conceptual question exhibits many, or most, of the following characteristics. Your conceptual question:

- is more open-ended.
- has the potential for more than one answer to adequately explain the phenomenon

- is more difficult to grade than your factual question.
- requires students to demonstrate skills of comparison, analysis or synthesis.

Sample conceptual questions are:

1. Explain the process that moved South America away from Africa. 2. What changes to this map would result from melting of the polar ice caps?

What is reasonable to state is that most factual questions require lower level thinking skills.

Remember Benjamin Bloom's famous taxonomy of thinking levels? (If not, see Table 1.) Factual questions generally use thinking skills from low on the taxonomy. Conceptual questions tend to require "higher level" thinking skills.

Title	Definition	Question
Knowledge	The ability to recall information	Name, list, tell, who, what, when, where
Comprehension	The ability to understand and explain information	Why, how, explain, describe, match, identify, restate
Application	The ability to use information in a new situation	Arrange, draw, dramatize, interview, sketch
Analysis	The ability to categorize information and to perceive similarities and differences	Classify, compare, contrast, graph, relate, diagram
Synthesis	The ability to create by combining more than one piece of information	Invent, design, predict, estimate
Evaluation	The ability to make judgments concerning given information, using supporting data	Support, decide, debate, choose, recommend, editorialize, determine

Table 1. Bloom's Levels of Thinking.

Another organizational scheme for thinking levels is presented by the California Science Framework. This model incorporates student cognitive developmental levels along with the thinking levels.

Grade Level	Science Process	Description

K-3	Observing, Communicating, Comparing, Ordering, Categorizing	One word descriptions
3-6	All of K-3 plus Relating	Generalizations, Principles, Laws
6-9	All of K-6 plus Inferring	Predictions, Implications
9-12	All of K-9 plus Applying	Inventions, Technology, Concepts, Rephrased laws

Table 2. Science Processes and Cognitive Development: Grades K-12.

Comparing Bloom's taxonomy with California's Framework model suggests that Bloom's lower taxonomic levels are developmentally most appropriate in grades K-3. It is, of course, ludicrous to suggest that higher level thinking can take place without adequate prior thought processes in the lower levels. It is equally inappropriate to suggest that once students begin using higher level thinking skills, that the lower levels should be abandoned. What is reasonable to state is that most factual questions require lower level thinking skills.

So how do we move students from factual to critical thinkers? There is a high probability that the bulk of assessment your students have experienced has been at lower taxonomic levels. To expect students suddenly to blossom into great critical thinkers able to provide cogent, coherent answers to conceptual prompts posed in your class is unrealistic. There is a need to transition from factual to conceptual assessment prompts. This "lack of transitioning" is another area where "teacher blame" for lack of quality student answers falls. I recommend that you begin preparing your students for conceptual prompts by providing transitional prompts early in your course. Part of the transition process is teaching some test-taking strategies. Loulou (1995, 2) suggests to students, "If you get stuck on a question try to remember a related fact. Start from the general and go to the specific… When answering an essay question, first decide precisely what the question is asking. If a question asks you to compare, do not explain." I am defining transitional prompts as those whose stem is stated in conceptual verbiage but which also include "clues" or "hints" for students as to the direction a response to the prompt might take. Sutman suggests:

> In order to provide students with the opportunity to think about and apply science concepts and to formulate complete thoughts in English, teachers should pose open-ended questions for them to answer. Assistance can take the form of providing references [emphasis mine], helping students to use English to express their questions and answers; and helping them develop investigations that will lead to answers… [T]his approach may result in coverage of less content, [however] students will have a deeper understanding of the material that is covered, and will, ultimately, learn more because they learned not only some science concepts but also how to problem solve (Sutman, et. al., 1993, 3).

Although Sutman is writing specifically about limited English speakers, we can consider most of our students to be "limited-critical thinkers" and apply his reasoning. We can provide "reference points" of differing degree. For example a transitional prompt might include any one three options shown in Table 3. Each succeeding type of clue provides less direction, helping students to move toward "assist-free" conceptual thinking.

Type of Clue	Sample Prompt
A list of terms to be included in the answer.	Compare the rate of the water cycle in a desert to the rate in a tropical forest. Be sure to include the terms solar energy, precipitation, evaporation, humidity and ground water in your answer.
Reference to prior experience.	Compare the rate of the water cycle in a desert to the rate in a tropical forest. Think about the experiment we did with the water in the 2-liter bottles.
Hints as to the type of terminology required for an acceptable answer.	Compare the rate of the water cycle in a desert to the rate in a tropical forest. Be sure to include correctly-used vocabulary terms from this unit.

Table 3. Types of Clues and Sample Transitional Prompts.

Another approach to the transition process is provided in the following example:

Brian, all 72 kg of him, bungee-jumps from a 100-m tower toward the river below. He falls 35 m before the bungee cord starts to stretch. This cord can stretch 40% of its length and has a breaking strength of 7000 N. Will this become a "free fall" for Brian, or will he "bounceback"?

Consider an alternate version of this problem, in which the last sentence is replaced by the following: "When the bungee cord has reached its maximum length, does the tension exceed the cord's breaking strength?" Several aspects of the first version make it more effective for encouraging students to think rather than simply to look for the appropriate quantities to "plug in" to a formula.

The first version does not specify what must be calculated; therefore, it requires students to decide for themselves just what the problem is and how their knowledge of physics can be used to solve it. Teachers can help students learn to solve problems of this type by first providing them with a set of general questions, such as: How are the objects and situations in the problem similar to any objects

or situations that were discussed in physics? [Notice the reference to prior experience!] Which variables are already in physics terms and which can be converted to physics terms? [Notice the suggestion to consider past vocabulary!] Are all of the pieces of information in the problem relevant to its solution? [This hint is similar to Loulou's test taking suggestions!] (Potts, 1994, 2).

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It may sound strange to you, but because of past experience, many of your students come into your class with no understanding that assessment relates directly to course content. Hints in transitional prompts help provide content-assessment connections. By starting a course with transitional prompts sprinkled among factual prompts, students will learn the expectations of an adequate answer to a conceptual prompt while achieving success during the learning experience. They also begin to understand how content fits into a conceptual prompt framework. As the course progresses, use of transitional prompts decreases in proportion to the implementation of conceptual substitutes-students are gradually weaned from the need for hints and clues. Transitional prompts can be used for longer periods of time with students who are developmentally unprepared for conceptual prompts. In some classes transitional assistance may be required only briefly in the beginning units of the course. In other classes, it might be appropriate for transitional prompts to be the predominant type prompt used in assessment for the entire course. In either case, or any case in-between, students are more challenged than they would have been by a steady diet of factual-only assessments. You might be surprised. I've had students who became offended when I assessed with too many factual prompts late in the semester or year. "What's the matter? You think we don't know this stuff so you're asking only easy questions?" is a typical complaint. And that is music to any teacher's ears.

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