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Examining Our Examinations

BY TOM GARRISON

A FEW YEARS AGO, a retired court reporter enrolled in my large general oceanography course. This diligent student used her considerable skill to take down, and transcribe, every word spoken and every data set presented through the course of our 16-week semester. She didn't miss a day. At the end of the class, she presented me with a thick tome containing the transcript and her ancillary notes. Of course, I was horrified to read the sentence fragments, asides, incomplete thoughts, and occasional errors in my presentations. I became a better lecturer because of her.

But that's not why I remember this particular student. She stands out because of an exam question, and because her response to the question highlights a growing problem in our academic world—the disconnect between learning and critical thinking. Here's the question:

1. Like Earth, Mars rotates eastward and receives most of its sunlight near the equator. If a tropical cyclone were to form in the northern hemisphere of Mars, which way would it rotate (when viewed from above)?
   a. clockwise
   b. counterclockwise
   c. randomly
   d. it wouldn't rotate

Now, this question is not a good one, as questions go, because there is neither enough water nor enough heat on Mars to generate tropical cyclones. But, leaving that aside and getting to the point, which is information transfer to a novel situation (cyclogenesis and Coriolis effect), I gave the question a try. Most students got it right (counterclockwise), and I was pleased.

Afterwards, the court reporter came to my office to challenge the question. She pointed out, correctly, that I had *never mentioned* storms on Mars. This question, she suggested, was hugely unfair—how could I ask a question on a topic that was not covered in the text or lectures? She had memorized her notes and was prepared to answer any direct question on the material at hand, but this request to think critically and apply her knowledge to new conditions was "a trick question."[1] Explanation of the purpose of a college curriculum—to stimulate critical thought and to apply logic to new situations based on analysis of previous outcomes—seemed to be lost on her.

Fast forward to last week. Two students expressed concern over their low grades in the three interval examinations they had taken, and wondered how they could do better on the upcoming final. I asked to see their notes, and they produced a staggeringly large deck of flash cards, a liberally underlined copy of the text, and a nicely fleshed-in review sheet. These two had clearly spent a great deal of time preparing for the exam. We looked over their previous exams together, and they were amazed to see that they understood the right answers when those answers were shown to them (by the answer key), but found it difficult to come up with the answers on their own. Like so many students these days, they had confused time-on-task with content mastery. They thought they "deserved" a high grade because they had spent many hours studying.

My exams are, in my opinion, not particularly demanding or difficult. But I do try to avoid simple "plug and chug" questions—memorization exercises that reward the flash-card enthusiast. For example, here's a pair of questions that usually catches flack when I use them:

2. When a phytoplankter remains below its compensation depth, it:
   a. will survive, but will grow much more slowly.
   b. will eventually die.
   c. will die immediately.
   d. [The question is meaningless.]

[1] The concept of "trick question" mystifies me. Is it any question to which a student doesn't know the answer? Do high school instructors intentionally try to "trick" students into a wrong answer? I don't think so, yet I hear the term surprisingly often.

3. The compensation depth for zooplankton is _____ that for phytoplankton.

a. higher (shallower) than
b. lower (deeper) than
c. the same as
d. [The question is meaningless.]

The fundamental difference between autotrophs and heterotrophs is the point here. A student might complain that I *never* discussed compensation depth in zooplankton (the idea is truly meaningless because zooplankters don't photosynthesize). Yes, but does the student have enough background to discover—on his/her own—the crux of the issue? Can "meaningless" be a correct answer? Sure. Again, can a student transfer learned information to a novel situation?

When a student says "But I studied 12 hours for this exam, and still failed!" I'm reminded of the consumer who "knows" she has money left in her checking account because there are still checks in her checkbook. I have great empathy for these students—they have worked hard, albeit inefficiently—because this method of information mastery has worked perfectly for them through their education up until now. Critical thought was the elephant in the high school classroom ignored by everyone. Teach to the test, memorize, drill, repeat. *Challenger* expedition from 1872–1876? Got the dates right? Fine, *but so what…?*

In my honors-level coursework I emphasize "so what?" At first, the students are reticent to hazard guesses about an observed phenomenon—why do all these thermometers say seawater boils at different temperatures?[2] The lab theme is: "The search for, and minimization of, experimental error." Everything done in that laboratory course involves this theme. After a few weeks, these students won't even order lunch without contemplating all the variables or wondering about replication, calibration, and standardization. Rationality triumphs!

And then there are the students who claim they just don't do well on multiple-choice exams (which, by necessity, I must use because my class is very large). They say they know the material thoroughly, and would gladly explain any point to me, but, well, multiple-choice exams are not their thing. Call their bluff and what happens? You can guess.

So, what does a dinosaur like me do about his exams? Well, by necessity I include a significant number of "plug and chug" questions to placate the flashcard makers. I use "two-step" questions that require the student to think along a simple chain: For example, match "pearl" to a phylum? OK, oysters make pearls; oysters are Molluscs. The questions I *really* like, though, are ones like these:

4. Earth rotates eastward at about

a. 1,000 miles per hour.
b. 500 miles per hour.
c. 55 miles per hour.
d. 10,000 miles per hour.
e. [Impossible to say without more information.]

I didn't provide the latitude, so (e) is the right answer. The flashcard artists will pick 1,000 miles per hour because I used the equator as an example when explaining Coriolis acceleration in class.

And then they will visit my office to complain. And I will listen patiently and then wonder what I can do to be a better professor.

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[2] See "Boiling for Science," *Oceanography* Vol. 19, No. 1, March 2006, available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/19_1/19.1_education.pdf