Clarifying Comments on the
AP Vertical Teams® Guide for Science

September 2010

The *AP Vertical Teams Guide for Science* (2009) provides teachers and school and district-level administrators with important information about structuring curricula and instruction so that more students can experience success in an AP science course. Successful participation in an AP science course, in turn, is a significant predictor of success in further science study in college. The Vertical Teams Guide (VTG) was created with this goal in mind, and it seeks to address that goal through accurate information and the use of practical and effective examples.

As part of the normal development and production of College Board resources, drafts of publications are vetted with subject-matter experts on various College Board committees as well was with external experts. In reviewing the published VTG, some science experts raised questions about a few of the examples in the Guide. The College Board welcomes this type of review and input not only because it identifies issues or topics that require clarification, but also because, in this instance, it serves to highlight the academic and scientific process, where experts can bring different interpretations to a topic and, in doing so, promote academic and scientific discussion.

This document addresses some issues found in the *AP Vertical Teams Guide for Science.*

I. Earth science example, grades 6-8

Page 48

Differences of opinion exist regarding the accuracy of some of the terminology used in this example and with the effectiveness of the lab demonstration included. The following statement regarding observation of atmospheric phenomena occurs on page 48:

> *Concrete classroom examples of how changes in air pressure and air density correspond to changes in temperature can provide students with real-world applications. Students can see how the abstract processes of equilibrium and interactions have an impact on the atmosphere and weather around them.*

This statement may seem to some educators to be worded "backward": The properties of air pressure and density are quite abstract, whereas temperature is something students can actually feel. The following is an alternate statement that might be used, instead:

> *Concrete examples of how changes in temperature affect air pressure and density can provide students with real-world applications. Students can see how the abstract processes of equilibrium and interactions have an impact on the atmosphere and weather around them.*

This change might allow teachers to better assist students in constructing new knowledge based on their foundational understanding of temperature and what happens when it changes. Middle school students are usually very familiar with temperature. However, they may not be as knowledgeable about abstract constructs such as air pressure and density. If the teacher begins with students' familiarity with temperature and what can generally happen when it changes, concrete examples can then be used to illustrate how changes in temperature affect properties of air such as pressure and density.

As part of this same instructional example, the following statement also appears on page 48:

> *The topical essential question forms the bridge between the classroom demonstration (as described in the scenario that follows) and processes in the atmosphere. As students observe the demonstration, they see the effect of changes in equilibrium in the atmosphere. The observations on the plastic jug can correspond to high- and low-pressure systems in the atmosphere. Students can draw further conclusions by observing and explaining why winds increase along fronts where the temperature of air suddenly changes.*

The topic of “fronts” (i.e., frontal boundaries) in this demonstration might evoke several misconceptions regarding wind and how air moves from areas of high pressure to low pressure. These areas are usually small "pockets" that are caused by differential heating, not frontal boundaries within the same air mass. Thus, the reference to “fronts” should be deleted. Likewise, the reference to "high and low pressure systems" corresponding to observations on the plastic jug should be changed to "air masses." The alternative statement below might prove useful in this situation:

> *… As students observe the demonstration, they see the effect of changes in equilibrium in the atmosphere. The observations on the plastic jug can correspond to air masses. Students can draw further conclusions by observing and explaining why winds increase as the temperature of air changes.*

Continuing with this same instructional example, some experts believe that the milk jug demonstration described on page 49 does not consistently produce observable results. A suggested alternative is the ice cube activity, which is included at the end of this document.

Page 50

In describing possible assessments for the milk jug activity, the VTG contains the following statement on page 50:

> *Students describe, in terms of pressure and temperature, the direction of air flow when the caps are removed, and compare their descriptions with those of other students.*

In order to prevent any misconceptions or misunderstandings regarding direction of flow, some experts believe that when students are at more concrete-operational stage of cognitive development (e.g., grades 6-8), teachers may consider an alternate demonstration, illustrating the direction of flow when parcels of air of different temperature (and consequent pressure) come in contact with each other. Including this demonstration prior to the student task (i.e., the ice cube activity or the milk jug activity) would make the need for further concrete illustrations explicit.

Page 50:

Continuing with possible assessments for the milk jug activity, the following statements are found on page 50 of the VTG:

- *Predict what happens to the volume of the various plastic jugs if the elevation is changed.*
- *Real-world application: If the surface of the Earth heats the air by conduction, how does this cause convection in air and help cool the surface on a hot afternoon*.

The concern raised by some experts is that the issues of elevation and heating are not addressed directly in the milk jug activity. Although significant, the inclusion of elevation and heating as factors affecting atmospheric conditions (conditions within the jug) may cause some misunderstandings if prior instruction does not occur. In order to facilitate better student learning, the overall relationship between elevation, temperature and air pressure, as well as methods of heating, could be explored prior to conducting this demonstration in class.

II. Cross-disciplinary Unifying Concepts for Science

Page 57:
The table of unifying concepts on page 57 of the VTG, under interactions for physics, lists the following topics: *electrical circuits*, *conservation laws/closed systems*, and *collisions*. Some experts believe that the specification that this is for closed systems is contrary to the idea that the sciences support each other. The College Board Standards for College Readiness serve to support the meaning of conservation principles in the broader context of open systems, since most scientific observations are done in open systems (weather, bio, etc.). Therefore, in order to support integration of the sciences, teachers must facilitate the understanding of the unifying concept of conservation principles for *all* systems, not just closed systems.

III. Free-body Diagrams

Pages 86-88:
The VTG presents some physics problems for students at the "exposure" level (grades 6-8) to solve. In the introduction to these problems (p. 86), the following statement is made:

> *Students associate forces with a change in motion of an object (speeding up or slowing down, and/or changing direction). They represent the forces acting on an object with a force arrow diagram (free-body diagram).*

While some science educators utilize the terms "free-body diagram" and "force diagram" interchangeably, others see distinct differences in the application of those terms. For some science educators, force diagrams emphasized in grades 6-8 are less formal than free-body diagrams, which are used in high school or college physics courses and which are illustrated differently. Force diagrams are appropriate for providing students with the opportunity to visualize the physics described in the problem; furthermore, the diagrams could be viewed as foundational to more complex representations of free-body diagrams in high school physics courses. However, in order to avoid possible misconceptions or misunderstandings for students in the middle grades, the statement above could be reworded as follows:

Students associate forces with a change in motion of an object (speeding up or slowing down, and/or changing direction). They represent the forces exerted on an object with a force arrow diagram.

Page 86:
The stem to Question 1 reads:

A student throws a tennis ball up with an initial velocity of 3 m/s. Air resistance is negligible. The equation that describes the motion is given by: $v_f = v_0 + at$

This presents an error of terminology: If the initial velocity is 3m/s and the direction of this initial velocity is defined as up (as in the problem statement), then a positive number means upward, since this problem is constrained to one-dimensional motion; plus or minus is the only indication you need for direction. Therefore, only answer "c" is in fact mathematically correct, not "d" as is listed on page 87.

In order for answer (d) to be correct, one must change the term "velocity" to "speed," so that the first part of the problem statements for Question 1 on page 87 reads as follows:

A student throws a tennis ball up with an initial speed of 3 m/s. Air resistance is negligible.

This change represents a correction, and will help prevent student misconceptions or misunderstandings regarding the usage of "velocity" versus "speed" in questions such as this. Changing the term "speed" in the stem of Question 1 will provide teachers with the opportunity to show that any direction can be chosen as positive. This is key in helping students to solve problems such as these.

Page 89:
The stem to Question 1 reads:

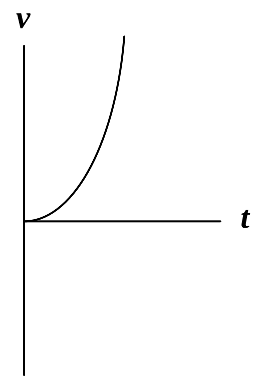
A student throws a tennis ball up with an initial velocity of 3 m/s. Air resistance is negligible. The equation that describes the motion is given by: $v_f = v_0 + at$

This presents an error of terminology: If the initial velocity is 3m/s and the direction of this initial velocity is defined as up (as in the problem statement), then a positive number means upward, since this problem is constrained to one-dimensional motion; plus or minus is the only indication you need for direction. Therefore, only answer "c" is in fact mathematically correct, not "d" as is listed on page 89.

In order for answer (d) to be correct, one must change the term "velocity" to "speed," so that the first part of the problem statements for Question 1 on page 87 reads as follows:

A student throws a tennis ball up with an initial speed of 3 m/s. Air resistance is negligible.

Page 88:
Questions 4 and 5 on page 88 each present four choices for graphically depicting the velocity of a ball on its way up (Question 4) and on its way down (Question 5); the same four answer choices are presented in each question. For Question 5, “d” is indicated as the correct answer. Some experts suggest, however, that “b” could also be a correct answer if the direction up is not specifically defined as positive. Therefore, they suggest that the following graph be substituted for “Graph II” in the problem, thereby allowing “d” to remain the correct answer.



This change will address the possible problem of confusing 2-D position with velocity graphs for projectile motion.

Page 91:
For the Intermediate level of instruction, Questions 5 and 6 on page 91 each present three choices for representing the motion of a ball on its way down (Question 5) and on its way up (Question 6); the same three choices are presented in each question. Some experts noted that, in Question 3 of the Intermediate level of instruction (p. 90), “*y*” represents vertical motion in the mathematical representations presented; however, in Graph I for Questions 5 and 6, “*x*” is used to represent vertical motion. Therefore, in order to promote consistent use of terminology and prevent any misunderstandings associated with the variations in labeling vectors, teachers may choose to replace “*x*” with “y” in Graph I of Questions 5 and 6.

Teachers may also want to clarify this point with students: Although *a*, *v*, and *y* in Question 3 on page 90 are defined with values, students should recognize that they are vectors and can be illustrated graphically as well as defined with values mathematically. This instructional tip will help address possible misconceptions regarding illustrations of vectors.

IV. Invasive Species

Page 95:
The stem to question 2 reads:

> *Name the country that was its original habitat and the name of the country to which it was introduced.*

In some cases it is appropriate to expect the student to be able to name the *country* that is the original habitat of the species, such as kudzu from Japan or wild boars from the United Kingdom. In other cases it is more appropriate for the student to identify the *region* that is the original habitat of the species, such as cane toads from South or Central America or zebra mussels from Eastern Europe.

Finally, an Intermediate level essay rubric for Environmental Science on page 146 presents the following sample essay question:

> *(b) Name the region that was the original habitat of the species and the country into which it was introduced.*

Following this question are several possible correct responses that students might offer; one of those examples is "Cane toad from Hawaii to Australia". A correction needs to be made for this particular example. The question above refers to the species' original habitat and the region that the species was introduced; the original or native habitat for the cane toad is Central and South America. The cane toad was first intentionally introduced into Hawaii, and then members of that population were intentionally introduced into Australia as well. Therefore a correct response on the rubric should be "Cane toad from Central or South America to Hawaii and Australia".

Laboratory Models

Ice Cube Activity[1]

One way to understand how inquiry works is by exploring the methods a student would use during an experiment. We will perform the following traditional lab together, in which you will play the role of a student. Then you will think about how to modify the activity to present it to students as both a part inquiry-based and full inquiry-based lab.

Experimental Question:
Does ice melt faster in fresh or salt water?

Pre-Laboratory Discussion:
1. Instructor should record the guiding question.
2. Students should:
   - Predict what would happen, considering how they think the properties of fresh water, salt water and ice will affect the results.
   - Translate their prediction to a statement or labeled diagram that explains the reasoning behind their prediction.

Materials:
- 2 clear plastic 10-oz cups labeled “fresh water” and “salt water.” Fill cups accordingly with:
  - 8 oz (250 ml) fresh water
  - 8 oz (250 ml) salt water (3–4 Tbsp salt per quart of water is approximately the salinity of open ocean seawater). Kosher salt is preferred.
    Note: Water should be the same temperature in both cups. Room temperature is fine.
- 4 fresh-water ice cubes, as uniform in shape and size as possible
- Spoon
- 1 vial, pipet *or* a bottle & eye dropper of dark-colored food coloring
- 1 thermometer
- paper towels

[1] Originally appeared in *Pre-AP Strategies in Science: Inquiry-Based Laboratories*, The College Board, 2010.

A. Laboratory Procedure (for students):

- Consider the question: If you placed one ice cube in each cup at the same time, which do you predict would melt faster? Why?

____

____

- Now use the spoon to place one cube in each cup of water. Observe both for 90 seconds. Record your observations. Which cube melted faster?

____

____

- Do you have any further explanation to match your observation?

____

____

- Gently add 4 drops of food coloring to each cup. Describe and record your observations.

____

____

- Provide an explanation for your observations.

____

____

Post-Laboratory Questions

- Does ice melt faster in fresh or salt water? Did your prediction match your results?

____

____

____

- When there is warm water and cold water in a cup, which ends up on the bottom? When there is salt water and fresh water in a cup, which ends up on the bottom?

- How does this knowledge help you explain why ice cubes melt faster in fresh water than in salt water?

- Using both words (a simple statement) and drawings, provide a scientific explanation for what you think happened in each cup as the ice melted.

- Provide a written explanation that would help someone distinguish between a cup of fresh water and a cup of salt water. Do not suggest tasting!

Questions for the teacher

B. Modifying a traditional lab: *part* inquiry-based

Think about how you would present the ice cube activity as a *part* inquiry-based lab. What kinds of instructions would you give? Would you need to modify the materials? How would you assess the lab? Write your ideas below.

C. Modifying a traditional lab: *full* inquiry-based

Think about how you would present the ice cube activity as a *full* inquiry-based lab. What kinds of instructions would you give? Would you need to modify the materials? How would you assess the lab? Write your ideas below.

D. Teacher Reflection:

Compare and contrast the inquiry-based learning experience with the traditional lab.

Turn to the person next to you and share your findings.