Student Performance Q&A:

2014 AP® Environmental Science Free-Response Questions

The following comments on the 2014 free-response questions for AP® Environmental Science were written by the Chief Reader, Alan McIntosh of the University of Vermont in Burlington. They give an overview of each free-response question and of how students performed on the question, including typical student errors. General comments regarding the skills and content that students frequently have the most problems with are included. Some suggestions for improving student performance in these areas are also provided. Teachers are encouraged to attend a College Board workshop to learn strategies for improving student performance in specific areas.

Question 1

What was the intent of this question?

This question was intended to determine students' knowledge of the potential impact of nuclear power plants on the environment. Students were asked to defend or refute statements about nuclear power plants producing no dangerous solid wastes or greenhouse gases. Students were asked to describe environmental problems that could result from building a nuclear power plant adjacent to a river, to discuss the consequences of pollution from the normal daily operation of the plant, and identify a system that is used to reduce that type of pollution. Students were asked to describe two specific steps that could be taken to reduce the use of electricity, and to identify a nuclear power plant that had a major accident and explain an environmental consequence of an accident at a nuclear power plant.

How well did students perform on this question?

The mean score was 4.39 out of a possible 10 points.

What were common student errors or omissions?

In part (a) common errors included not identifying that the wastes produced by a nuclear power plant were radioactive in part (i) and not providing a correct justification in part (ii). Many students correctly described water vapor as a greenhouse gas.

In part (b), students incorrectly described radioactive waste as an environmental problem during the construction phase of the plant. Additionally, students tended to identify, rather than describe the environmental problems associated with building the nuclear power plant.

In part (c)(i), students incorrectly identified air pollution or radioactive contamination as the main pollution threat to the Fremont River as a result of the normal daily operation of the plant. When this occurred, students did not get credit for parts (ii) or (iii). Although some students correctly identified thermal pollution as the most likely threat in (i), they incorrectly identified the water from the reactor core as the source of the heated water.

In part (d), students frequently described alternate methods of producing electricity rather than methods of reducing electrical consumption. Students tended to list, rather than describe, how a given strategy would reduce electrical consumption.

In part (e), the majority of students were able to correctly identify a major nuclear power plant accident. Students did not have to link an environmental consequence of a nuclear power plant accident to the accident they identified, however, if linked, the environmental consequence had to be correct. Students incorrectly identified human health issues as a consequence and frequently stated that everything died and dead zones were created.

Based on your experience of student responses at the AP® Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

Teachers should consider the following to enhance student performance:

- Encourage students to read the question multiple times before answering the question and remind them that merely restating the question is not answering the question.
- Remind students to respond appropriately to each prompt. When asked to describe or explain something, they should write the most complete answer they are capable of writing. If asked to simply identify something, a brief answer should be given.
- Spend time in the course comparing and contrasting different methods of producing electricity, including traditional and alternative methods.
- Give students projects relating to their electrical consumption and have them explore methods to reduce their electrical consumption.
- Remind students to be careful with their wording. Avoid vague terms such as "pollution." Additionally, "buying" an item is not the same as "replacing" or "upgrading" an item.

Question 2

What was the intent of this question?

This question was intended to determine students' knowledge of problems associated with storm-water runoff. They were asked to identify pollutants in runoff and to perform calculations relating to the volume of storm-water runoff and the amount of untreated storm water that would bypass a water treatment plant after a certain rain event. Students were asked to describe two strategies for reducing storm water runoff and to describe a non-pollution-related problem that would result from having extensive paved areas.

How well did students perform on this question?

The mean score was 2.80 out of a possible 10 points.

What were common student errors or omissions?

Students did relatively well on part (a) of the question. However, many students identified "sewage" as the pollutant, without identifying a specific component of sewage. Likewise, many students were confused about the distinction between air pollutants and water pollutants, identifying specific air pollutants that would not be found in water (e.g., SO_x, NO_x, carbon monoxide).

Many students incorrectly converted centimeters to meters in part (b) by dividing by 1,000. Many students attempted to calculate a daily rate of runoff by multiplying their volume by 24 (hours). Many students transcribed numbers from one calculation to the next incorrectly, and many students gave incorrect units in their answer (e.g., m^2 instead of m^3).

Many students incorrectly converted km^2 to m^2 in part (c) by multiplying by 1,000 rather than 1,000,000. Students also made errors while working with scientific notation, often giving answers that were off by 1

decimal place. After calculating an incredibly small amount of runoff (e.g., 10 m^3), many students also failed to notice that their answer to (c) was not logical, especially compared to their answer in part (b). Many students failed to do basic math correctly, sometimes adding, subtracting, or dividing, where they meant to multiply.

Many students failed to earn the point in (d) because they did not understand what calculations were required to get them to the right answer. Many students added the volume of runoff from the parking lot to the volume of runoff from the town, not realizing that the mall would already be included in the volume of runoff from the town as a whole.

The most common error in part (e) involved students simply identifying a strategy to reduce runoff rather than describing how the strategy would reduce runoff. For example, students identified removal of impervious surfaces as a strategy for reducing runoff but failed to explain that by doing so, water could infiltrate the soil. Many students described ways of getting water to drain to nearby waterways more quickly, or ways to get the water to a holding tank to be treated by the FWTP once it could handle the volume, but such strategies do not decrease the amount of runoff. Another common error committed by students involved describing a strategy that would minimize the *increase* in runoff (e.g., constructing new parking lots made of gravel instead of pavement), rather than a strategy that would decrease runoff (e.g., replacing paved parking lots with gravel parking lots). Many students suggested building "watersheds" or using "drainage basins" to capture water, not realizing that these terms mean something different from what they were describing.

The most common error committed part (f) of the question involved students simply identifying a problem rather than describing the problem. Many students described a problem involving pollution, in spite of the fact that the question asked "other than pollution." Many students describing habitat destruction or biodiversity loss simply stated that habitat destruction would lead to biodiversity loss, rather than providing a valid description of a mechanism for habitat destruction or biodiversity loss. Many students describing the urban heat island effect did not explain that solar radiation/heat was both absorbed and radiated by impervious surfaces. A surface that just absorbs heat/radiation would actually cool the surrounding air rather than heating it up.

Based on your experience of student responses at the AP® Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

Teachers should consider the following to enhance student performance:

- Encourage students to read questions carefully and answer in complete sentences, especially when the questions ask for a description.
- Help students understand that a question asking for a description of a strategy/problem/etc. should include both identification of a strategy/problem/etc. and an explanation of how their identified strategy/problem/etc. answers the question.
- Help students understand the distinction between air pollutants and water pollutants.
- Help students understand what runoff is and what steps can be taken to minimize runoff.
- Explain problems directly caused by having excessive amounts of pavement.
- Teach students how to perform dimensional analysis (including all units in the setup) and how to do simple calculations without a calculator.
- Encourage students to show all work, including "mental math," since some students doing mental math on this question made foolish errors.
- Emphasize how to work with scientific notation and exponents.
- Help students convert within the metric system and, in particular, how to convert 2- and 3-dimensional values (areas and volumes). Finally, teachers should instruct students to show all necessary work and calculations within the space provided in the question rather than using the inside cover or the first page of the test booklet.

Question 3

What was the intent of this question?

This question was intended to determine students' understanding of volcano, tsunami, and earthquake formation as they relate to changes in ecosystems. The students were asked about plate activity in subduction zones, tsunami formation, soil formation through ecological succession, and the ecological impact of tsunamis.

How well did students perform on this question?

The mean score was 2.69 out of a possible 10 points.

What were common student errors or omissions?

In part (a) students regularly confused different types of plate boundaries, often confusing convergent and divergent boundary types. Most students did not include any discussion of plate density in their explanations of subduction. When students did discuss density they often incorrectly identified the denser plate.

In part (b) many students confused primary and secondary succession, and discussed them interchangeably. Students often discussed chemical and mechanical weathering of rock, but did not include the role of organisms in the development of soil as part of the succession process.

Many students are able to describe the cause of a tsunami as an "underwater earthquake," but most were unable to physically describe the interaction between plates that leads to the displacement of water involved in a tsunami. Students often described the generation of a tsunami as occurring when an earthquake "shakes" or "stirs" the water, but did not describe how the earthquake displaces water.

Frequently students confused tsunami waves with tidal waves and storm surge.

In part (d) many students demonstrated an understanding of the relationship between transform faults and earthquakes, but many confused transform faults with divergent boundaries and described the plates "pulling apart."

Many students were not able to communicate the dynamic nature of plate tectonics and often described the plates as simply moving or not.

Based on your experience of student responses at the AP® Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

- Plate tectonics would be a great place to reinforce some basic concepts like mass, density, pressure, velocity, etc. Have students practice writing descriptively with regard to space and time. Learning how to describe motion, time, and spatial directions would help to prepare for this type of question.
- Help students to understand primary and secondary succession as processes and not just vocabulary. Reinforce the role of physical, chemical, and biological factors in soil formation.
- Work with students to become better communicators through writing descriptively. Use diagrams of processes and events like succession and tsunamis as prompts to have students practice verbalizing and describing what is occurring in the process.
- Remind students to pay close attention to the language in the question prompt. Students often provide economic impacts when asked for ecological impacts and vice versa.

- When discussing plate tectonics reinforce the dynamic nature of plate movement. It is easy to discuss volcanoes, earthquakes, tsunamis, etc., as isolated events, but students will be able to better write about these phenomena if they understand them within the context of a dynamic crust.

Question 4

This question was intended to determine students' understanding of biogeochemical cycles. In particular, the question focused on the carbon cycle and students' ability to identify terrestrial and oceanic sources, sinks, and reservoirs of carbon, as well as the form of carbon in these reservoirs and the processes that move carbon from one reservoir to another. The last part of the question focused on the phosphorus cycle.

How well did students perform on this question?

The mean score was 2.72 out of a possible 10 points.

What were common student errors or omissions?

In general on this question the most common student error was in not providing a complete or detailed enough description or discussion. For example, many students were able to identify photosynthesis in (a)(i) and respiration in (a)(ii), but a significant number of students failed to describe the specifics of either of those processes. In addition, many students are under the impression that the purpose of photosynthesis is to convert carbon dioxide into oxygen, and/or that oxygen is an organic molecule.

In (b), many students had difficulty in distinguishing between carbon reservoirs and carbon sinks. Students had the most difficulty with identifying a terrestrial sink that would store carbon for thousands to millions of years (many gave short-term carbon sinks, such as "animals").

The most common error in (c) was discussion of a human activity that involved burning fossil fuels such as "driving automobiles." It wasn't always clear from the responses if the student had not read the question carefully, or if the student didn't understand that fossil fuels are used to power most automobiles. In addition, many students cited "respiration from a growing human population" as a source of increasing carbon dioxide in the atmosphere. Breathing is an involuntary action and is not considered a human activity.

The most common problem in (d) was failure to provide a complete discussion of an environmental consequence to the identified problem. Most students were able to identify problems such as global climate change, sea level rise, or melting of ice caps and glaciers, but then failed to specifically discuss an environmental consequence of the identified problem. A significant number of students continue to confuse global warming and stratospheric ozone destruction, and identified "destruction of ozone due to increasing carbon dioxide" as an environmental problem. In addition, a number of students identified "global warming due to the ozone hole" as an environmental problem.

A large percentage of students were able to correctly discuss one way in which the phosphorus cycle differs from the carbon cycle in (e)(i). Far fewer students were able to specifically identify why phosphorus is necessary for organisms in (e)(ii). Many made sweeping statements such as "phosphorus is a necessary nutrient."

Based on your experience of student responses at the AP® Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?

Environmental science students should be able to demonstrate a deeper knowledge in their answers to questions than a student who has not taken the AP® Environmental Science course. The following recommendations to teachers can aid in improving student performance on exams:

- Students should avoid answers that are really just a restatement of the question. For example, in (a)(i) many students simply said "photosynthesis is a biological process in which carbon is removed from the atmosphere and converted to organic molecules." This is not the level of detail expected from AP® Environmental Science students. APES students should be able to give "value added" answers, more along the line of "plants take in atmospheric carbon dioxide and through the process of photosynthesis use this carbon to produce glucose, an organic molecule."
- Teach students to "follow through" on descriptions and discussions. For example, in (d) many students identified global warming as an environmental problem resulting from elevated atmospheric carbon concentrations. In many cases the environmental consequence given was "sea level rise" without any explanation of WHY sea level rise is a problem. Without a complete discussion of why sea level rise is a problem, it could be argued that if you are a fish, sea level rise is a good thing — negating "global warming" as an environmental problem.
- There continues to be a problem with students confusing global warming/the atmospheric greenhouse effect and stratospheric ozone destruction. Teachers should continue to help students differentiate between these.