Student Performance Q&A:

2015 AP® Environmental Science Free-Response Questions

The following comments on the 2015 free-response questions for AP® Environmental Science were written by the Chief Reader, Alan McIntosh of the University of Vermont. 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 based on a mock newspaper article that discussed the Florida Everglades. The intent of this question was to have students demonstrate knowledge of the potential impacts of changing water quality and quantity on a wetland ecosystem. Students were asked to describe two human activities, other than anthropogenic climate change, that decreased the amount of freshwater flowing into the Everglades ecosystem. Students were asked to apply knowledge of the phosphorus cycle by describing a human activity that increased phosphorus levels in the Everglades and by explaining one way in which increased phosphorus levels adversely affected the Everglades ecosystem. Students were asked to describe a step that could be taken to reduce phosphorus inputs into this system. Students were asked to identify and describe a specific example that demonstrated the impacts of climate change on water quantity, water quality and habitat in the Everglades ecosystem. Students could extrapolate general knowledge of the effects of climate change on coastal and/or wetland ecosystems to answer this portion of the question. Finally, students were asked to describe how improved water quality and quantity would improve the structure and function of this ecosystem and how the restoration efforts would benefit the economy of Florida.

How well did students perform on this question?

The mean score was 2.92 out of a possible 10 points.

What were common student errors or omissions?

In part (a) common errors included not describing the human activity that was identified. Students also incorrectly identified water being diverted by dams to produce hydroelectricity as a human activity that decreased the amount of water flowing into the Everglades ecosystem.

In part (b)(i) students incorrectly identified burning fossil fuels or phosphate mining as a specific human activity that contributed to increased phosphorus levels in the Everglades, therefore, many of their solutions offered in part (iii) did not earn credit. Additionally, in part (b)(i) students frequently confused pesticides with fertilizers as potential sources of phosphate runoff. The majority of students who earned a point in part (i) correctly explained the impact of increased phosphorus on the Everglades ecosystem in part (ii). In part (iii) students incorrectly identified manure or organic fertilizers as substances low in phosphorous.

In part (c) many students correctly described evaporation due to increased temperatures as a reason for decreased water quantity as a result of climate change. Students did not earn credit for changes in water quality by saying climate change caused a change in temperature or levels of dissolved oxygen if the direction of change was not specified. Students incorrectly identified acid rain as a consequence of climate change. Students did not earn credit for saying that habitats were changed due to climate change and species had to leave.

In part (d)(i) common errors included just restating the question instead of describing the impact on the ecosystem. Additionally, students confused restoring biodiversity with increasing biodiversity in an ecosystem.

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.
- Remind students to be careful with their wording. Avoid vague terms such as "it changes."
- Teachers should review the impacts of climate change on various ecosystems including wetlands and coastal ecosystems.
- Help students understand what runoff is and what steps can be taken to minimize runoff.
- While reviewing the biogeochemical cycles with students, include the impacts on the environment of those substances.
- Remind students that even if topics, such as fertilizers and pesticides, are covered in the same chapter, they can have different impacts on the environment.
- Apply concepts learned in class to real-life examples. For example: "How has climate change impacted national parks in the United States?" or "How have irrigation practices impacted the Aral Sea or the Ogallala aquifer?"

Question 2

What was the intent of this question?

The question was intended to determine whether students could use the given information about mobile device sales over time, along with device composition and recycling rates to work through a series of calculations. They were asked to determine growth rates, the mass of gold, and the amount of e-waste produced. The three parts increased in complexity. The next part of the question asked students to identify a negative human health effect of mercury. The final part of the question asked students to state two reasons why e-waste is often shipped from the U.S. to other countries for recycling and disposal, and how retailers or manufacturers might offer realistic programs to reduce e-waste.

How well did students perform on this question?

The mean score was 3.32 out of a possible 10 points.

What were common student errors or omissions?

In parts (a), (b), and (c), students often failed to show their work. Students should remember that when the word "calculate" is used in math problems, teachers and graders will be expecting to see the math work, including correct numbers, all required units, and ideally cancellation of units in the calculation to show how the correct answer was determined. If the working numbers are given as common or metric units like "million" or "mg," these units should be carried into the calculation or converted into whole or real numbers as appropriate. All of the steps must be clear to provide the entire, correct calculation for full credit. Calculations should be done in legible, reasonably sized numbers, letters, and symbols. In several cases, a multiplication problem was set up and indicated, for one point, but the student actually performed an incorrect calculation (i.e., division instead of multiplication) to arrive at an incorrect answer. Students should take special care when working with or reducing powers of 10, as several correct math setups did not arrive at the correct answer because decimal points were moved incorrectly.

In part (d) students obviously knew a lot of potential negative human health effects. The key to a correct answer in part (d) was that it was a specific human health effect that resulted from exposure to mercury. Quite a few answers listed death as an answer even though it was specifically excluded in the question. In addition, many answers just restated the question in general terms without a specific negative human health effect listed. In some cases, students gave answers that were not considered human health conditions, such as vomiting. Such answers were not accepted, since they are temporary, often only one episode, and could also be seen in other common human actions, such as drinking too much water or overexertion. There is also a lot of speculative information (particularly on the Web) about negative human health impacts of mercury exposure, and some websites state unsubstantiated negative human health effects of mercury as fact. Unsubstantiated negative human health impacts were not accepted. Students also listed some negative human health impacts (i.e., Itai-Itai disease) that are not caused by mercury. Some general human health effects, such as "birth defects," were also accepted because they were tied directly to mercury exposure in documented studies in a more general way. Students are urged to be as specific in an answer as possible.

Students generally did well on part (e)(i) of this question. The most common error associated with (e)(i) was to only state one reason rather than two. Another common error where points were not earned was to concentrate on why a less-developed country might like to **receive** the e-waste (i.e., "the developing country could use it as a resource"), rather than the reasons why U.S. companies might ship it to that country, most of which are cost savings due to a differential in cost or regulation between the U.S. and the receiving country. Students often answered in general terms (i.e., "the U.S. doesn't want the e-waste"), rather than stating more realistic reasons, such as cheaper labor or less regulation in developing countries compared to expensive labor or high regulation in the U.S. Lack of landfill space did not earn credit because it is also not the reason for shipping e-waste overseas. Simply writing down a word, such as NIMBY, even with a definition, didn't answer the question and did not earn credit unless it was explained how this could result in the transfer of e-waste from the U.S. to another country.

In part (e)(ii) the most common problem in answers that didn't earn credit was that students based the answer on U.S. government or consumer initiatives and actions rather than retailers' or manufacturers' initiatives and actions. The second most common reason why an answer didn't earn credit was when the student suggested a substitution that didn't result in a clear reduction of mass of e-waste or include reuse or recycling of part of the e-waste, which would reduce the amount of e-waste. Often the response mentioned substituting something for mercury or just suggested using "less toxic" materials in

construction. Based on the number of times the word "mercury" appeared, it is clear that students continued the consideration of negative mercury impacts into this part of the question.

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?

- Ask students to be sure they have written two clear answers when two are requested.
- Ask students to spend a bit more time reading and understanding the question asked before they begin to craft an answer.
- Suggest students circle or underline key words in the question.
- Teachers should give students the opportunity to use math in environmental science contexts.
- Review dimensional analysis with students, including units required in the answer, units in the numbers given with the problem, and how to cancel units to solve the problem.
- Scientific notation and use of exponents is helpful and often results in easier calculations.
- Because the directions say to "show all calculations," teachers should make it clear that even if a student does a calculation in their head, they should show that calculation in their response to earn full credit.

Question 3

What was the intent of this question?

The intent of this question was to determine students' knowledge regarding oil spills and oil spill cleanups. The question required the student interpret a graph, discuss problems associated with oil spills, discuss the advantages and disadvantages of oil spill response methods, explain other ways that oil enters aquatic ecosystems, and to identify a replacement for petroleum in consumer goods.

How well did students perform on this question?

The mean score was 4.30 out of a possible 10 points.

What were common student errors or omissions?

In part (a) students often thought that they needed to complete some calculations in order to determine the maximum volume of oil during the Deepwater Horizon oil spill. They often attempted to average the low estimate and high estimate, which gave them a value that fell outside of the acceptable range. Students also attempted to answer with a range, while the question called for the students to "determine" the value, which leads to a single number.

In part (b) students did a good job of addressing the prompt to give environmental problems and not problems of an economic nature. Sometimes the responses were too vague to earn points. Students would often write about habitat loss or toxicity to organisms in a way that was too broad or oversimplified to be considered a direct impact of the oil spill.

In part (c) most students earned credit. Sometimes students would identify an economic impact that was either not true, or something that was logical but not supported in the literature.

In part (d)(i) the most common mistake was that students often wrote about chemical dispersants either cleaning up or removing the oil. Dispersants break down the oil into smaller droplets which can allow bacteria to degrade the oil faster. However dispersants themselves do not remove the oil from the water.

In part (d)(ii) students were generally successful in identifying and describing either a biological or physical method of oil spill cleanup. Most students chose to discuss a physical method.

In part (e) some students had a difficult time identifying a source of oil other than oil spills. They often proposed a different type of oil spill. Most students were able to identify a source and describe runoff as the process by which oil found its way to the ocean.

In part (f) most students were able to identify a product and a replacement. Some students chose materials that were so experimental that they didn't qualify as consumer goods.

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?

As science teachers, it is important to expose students to breakthroughs in our field. There is, however, an inherent danger to introducing cutting-edge science to students. If the teacher does not take great care to frame the importance of a single discovery within the context of broader scientific knowledge it is possible that students will overvalue the knowledge that is gained from that piece of research alone. It is possible that the students will see the new research with a level certainty that should be reserved for well-established concepts and well-tested theories.

In the student responses regarding petroleum replacements, we received many responses that included examples of interesting breakthroughs in the area of alternative plastics. Many of these breakthroughs, however, were the result of only a very small body of research, anecdotal observations, or even children's discovery labs. Many of these examples were years away from production or commercial use, if ever. Many examples were simply not feasible at the industrial scale for the time being, and many were the result of once-promising research that ceased years ago.

While these cutting edge examples are exciting, they do not necessarily represent the concept that we want our students to learn or reflect what is practical. When students use these examples on the AP Exam, they are obscure to the level that they might not be recognized or included as correct responses. Our recommendation is that current research definitely has a role in inspiring our students, but that we as science teachers should make an effort to discuss these discoveries within the larger context of scientific knowledge. We should also strive to help our students focus on learning and being able to communicate the important concepts and proven examples.

Student responses to this question about oil spills served as a reminder that we as scientists and science teachers should work to make sure that the information that we give our students is truly scientific in nature. Many responses regarding the impacts of oil spills, and the impacts of dispersants were logical, but not necessarily factual. The research in these areas is not as complete as one might expect. As we interpret the science to our students, we often need to fill in the gaps with logic, but it is important that we differentiate between what we know and what we think.

Question 4

What was the intent of this question?

This question was intended to determine students' knowledge regarding the causes of urban sprawl. Students were asked to discuss two human effects associated with urban sprawl. Students were next asked to describe the relationship between population density and petroleum use shown in the graph provided. Students were asked to describe two steps a municipality could take to encourage smart growth in order to limit urban sprawl and to describe two methods to reduce harmful effects on wildlife populations from

highways and urban sprawl. Students were next asked to describe one practical way to increase food production within urban areas.

How well did students perform on this question?

The mean score was 3.31 out of a possible 10 points.

What were common student errors or omissions?

In part (a) common errors included describing urbanization, instead of urban sprawl. Students may not have carefully read the sentences, "The term 'urban sprawl' describes the expansion of cities into rural areas. This phenomenon has occurred around the world and has had economic, health, and environmental consequences."

Many students wrote about urban growth and industrialization, and lacked a description of low-density development on the edges of cities, the expansion of human populations away from the central urban areas into low-density, usually car-dependent communities. Many students described urban sprawl as being characterized by people moving into the central urban area in large numbers.

In part (b) students often provided a vague/incorrect human health effect(s); e.g., "increased exposure to disease," "increased disease spread," "health problems," "health issues," or "respiratory problem."

In part (c) students did relatively well. However, some students described the relationship as involving population size instead of population density.

In part (d) common errors included students describing zoning, but not including any supporting information with zoning, such as modifying zoning ordinances to encourage multi-use/mixed-land/property use/ development or promoting other similar compact development steps. Students also described birth-control measures and limitations on family size as ways to encourage smart growth.

In part (e) students described not building highways or not building highways outside of city limits rather than describing a method to reduce harmful effects on wildlife populations from highways and urban sprawl.

In part (f) students described the preservation of agricultural lands in rural areas near cities, the use of farmers markets, subsidizing farmers, and agricultural practices, such as crop rotation rather than describing how to increase food production **within** urban areas.

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 carefully read all information provided in a free-response question, including information printed to introduce a free-response question such as the two sentences that precede part (a). Encourage students to read the entire question several times before starting their written response.
- Remind students to respond directly to what each question is asking, but not to restate the question in their responses.
- Encourage students to be careful with their wording in order to avoid vague terms such as "pollution," "health problems," and "overall unhealthful."
- Provide opportunities for students to analyze and construct graphs throughout the course.
- Devote time in the course comparing and contrasting urban sprawl/suburban sprawl/urbanization (IV.D.1. in course outline), as well as sustainable land-use strategies.