Student Performance Q&A:

2016 AP® Environmental Science Free-Response Questions

The following comments on the 2016 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?

The intent of this question was to test a student's ability to synthesize and evaluate problems in population and ecosystem biology/ecology and emerging infectious diseases. Although the Fremont Press article discussed many aspects of the little brown bat, this question was less about bats and more about the impacts of small and declining populations.

The first part of the question asked students to provide an explanation for why a disease, such as White Nose Syndrome (WNS), seldom causes extinction of its host species. The next few parts ask how the surviving bat populations respond to their small number and size. In part (b) students were asked to describe two threats to the species' survival, given the very small population size. They are then told that recovery of this small population will be slow and are asked to discuss one aspect of bat biology that contributes to this slow recovery time. In part (c) students were asked to describe how a decline in the bat population affects other organisms in an ecosystem. In part (d) students were asked to identify two ecosystem services that forests provide, and to explain how each service benefits human society. The final part expands on the idea of a disease's impact on a population. In part (e) students were asked to provide a correct reason and explanation for the increase in emerging infectious diseases that are affecting human populations.

How well did students perform on this question?

The mean score was 4.62 out of a possible 10 points.

What were common student errors or omissions?

In part (a) students correctly explained that genetic variation (resistance/immunity) among individuals occurs and helps them survive, however, they neglected to demonstrate the contribution of that resistance to the next generation. Some students incorrectly linked acquired resistance or immunity during exposure that would then pass on to other generations.

In part (b)(i) many students presented general threats to species survival without the special consideration of small population size. Many students suggested the population would be more vulnerable to predators without giving a reason other than there were fewer bats. Students also discussed problems with reduced biodiversity when they meant genetic diversity.

In part (b)(ii) students often repeated from the article that little brown bats lived for 10 years and had 1–2 pups per year without saying how this would impact the slow recovery rate of already small populations. Students would sometimes describe the type of strategist or survival curve that bats represented incorrectly saying they were r-strategists or display a type II curve. In addition, students would sometimes use the information from the article incorrectly such as saying that a little brown bat only has 1–2 pups in her entire lifetime of 10 years.

In part (c) the most common omission was not stating the direction of impact on prey and predator species. For example, students often described how insects eaten by bats were impacted/affected without saying those populations increased. For predators of bats, students often spoke of the predator species having to change to another food resource without a specific effect on the predators.

In part (d) students did a good job of identifying a forest ecosystem service but sometimes did not accurately explain the benefit to human society. The most common mistake was identifying oxygen as an ecosystem service but then linking it generally with "human survival" rather than our need for oxygen for cellular respiration. Students also commonly referred to "carbon sinks" but then incorrectly explained the need for clean air. Students did not earn any credit if the ecosystem service was not directly linked with a correct human benefit. Some students focused on the economic services, rather than ecosystem services, which did not yield them any points. Another common omission was students identifying two different benefits for humans, but only one ecosystem service.

In part (e) the most common mistakes were students identifying an increase in human population size or growth (instead of density) as why there is an increase in emerging infectious disease. Another common error was not giving a direction for change. For example, students might discuss transportation or travel without mentioning how this has recently increased globally. Commonly students omitted the additional explanation especially in reference to climate change when students would neglect to add how this led to disease-carrying vectors increased access to places that were previously too cold. Some students would generally discuss rising temperatures, but would not define whether these temperatures were air, water or soil or global, regional or local. In both parts (d) and (e) students are still confusing climate change and ozone depletion.

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?

- When presenting on evolution and adaptation, reinforce the idea of random genetic variation among individuals and how, without reproduction, these traits can't change frequencies in a population over time. Demonstrating the process of co-evolution with specific disease vectors and hosts would also enhance the students understanding of this concept.

- When reviewing ecology, emphasize the different questions asked at each level (population, community, ecosystem) with specific examples of each. When discussing populations, review the impacts on small populations especially with reference to problems associated with reduced genetic diversity. This is especially important now as wild animal populations continue to decline. With regard to ecosystems, stress the importance of interactions among species and how the removal or decline in one can influence many others.

- When reviewing life history variables and population dynamics, remind students how r- and K-strategies can explain many characteristics of a species.

- Students need to be reminded how important ecosystems are to our survival. They provide a multitude of human services from ecological to cultural.

- Students often misidentified the process of photosynthesis by stating that carbon dioxide gets converted into oxygen which is then released and used for organismal survival. It would be helpful to review this process to ensure that students understand the source of each of the products and to realize that the released oxygen byproduct is not from the carbon dioxide, but is from the water molecule.

- Emerging infectious diseases are increasing globally for a number of reasons. A good time to discuss this phenomenon is during the impacts of climate change.

- Remind students to be precise with their scientific vocabulary — in this case the difference between immunity and genetic resistance. Exposure and resulting immunity occur during a life-time and are not heritable. In addition, biodiversity is not synonymous with genetic diversity.

- General comments

    - Remind students to read the question more than once and answer every aspect. Advise them to take a moment to think about the general concepts they have learned and how they are connected to the questions.

    - When answering the "article" question remind students to read it more than once, to be accurate, and to refer back to it when prompted.

    - Students should be careful with their wording. Remind them to use terms they learned in class and to avoid generalities such as "is impacted" or "causes changes." Make sure they provide directionality when needed.

    - Review with your students the difference among "identify," "explain," "describe," and "discuss." Make sure they use full sentences on the exam, even when asked to identify.

    - Always try to relate concepts learned in the classroom to real-life examples. For example, the recent Ebola and Zika outbreaks can be reviewed for how infectious diseases emerge and their impact on populations.

Question 2

What was the intent of this question?

The intent of this question overall was to have students evaluate several different items associated with the production of iron, steel, and coal. A set of data was presented, and a narrative asked for students to answer different questions associated with the production of iron and steel.

In parts (a) and (b) students needed to understand mass conservation, and to be able to select the correct information for calculations of iron production, resource depletion, and the impact of recycling on the use of raw resources. In parts (c) and (d) students were asked to consider and describe environmental problems and solutions associated with coal mines. Part (e) required students to discuss why surface coal mining is less expensive than subsurface mining.

How well did students perform on this question?

The mean score was 3.25 out of a possible 10 points.

What were common student errors or omissions?

The most common omission from parts (a)(i), (a)(ii), (a)(iii), and (b), other than not attempting an answer, was an incorrect setup of the calculation. Generally students understood what was asked, set up the calculation, and came to a correct answer. In some cases, quantities weren't stated correctly; for instance, the word "billion" or "million" was omitted. In other cases, order-of-10 errors were seen. Where complete dimensional analyses were used and presented, students did quite well. Unexpectedly, there were some math errors when the numbers from the table were converted to scientific notation, although these were not as common as math errors where scientific notation was not used. It seemed clear from some of the incorrect answers after students showed a correct setup that some students had not memorized basic times tables.

Primary problems with student responses to parts (c) and (d) included a lack of focusing in on a real environmental problem. In some cases, the problems presented were quite vague, using words like "pollutant," "toxic," or "contaminate" without defining what the specific problem was. In many cases, the description of the problem had little or nothing to do with coal mines or was even presented outside of the context of coal mines entirely. Students often described one problem and omitted the second description in part (c). Sometimes students presented a solution in part (d) that wasn't tied to the problem in part (c).

Part (e) was rarely answered correctly. Part (e) was commonly missed by focusing on costs associated with equipment, or difficulty in using it, rather than labor costs of salary, number of people required, safety, health care, and legal costs. Another common misconception was that the environmental costs were greater for underground mining, which is not correct.

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 review fractions, percentages, differences, and per unit concepts.
- Teachers would be wise to work through some math problems related to environmental science, including all units, setup, calculation, cancelling units, and determining whether the answer seems reasonable given the question.
- Make sure all students can recite times tables to the point of using long math-on-paper techniques to solve problems.
- Review dimensional analysis with students, including units required in the answer, units in the numbers given with the problem, and how to determine units inside of and that need to be cancelled to solve the problem.
- Cover scientific notation and use of exponents.
- Teachers should make it clear to math-gifted students that if that student does a calculation in their head, that they should also write down that calculation in the answer. In some cases, correct answers didn't earn any or all credit due to insufficient written setup of the answer.
- 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 before they begin to craft an answer.
- Ask students to circle or underline key words in the question.
- Ask students to restate the essence of the question (usually a couple of words) in the written answer to help make sure that the words in the answer do answer the question.

- In the case where a specific item is asked for, it might be good to add that at the beginning of the answer. For instance, an answer to e) could start with "Surface coal mining is generally less expensive than subsurface mining because…" and then finish the sentence with the answers to the question.
- Teachers should review use of math in general for environmental science, including getting students to accept that numbers and use of math is an essential part of an understanding of environmental science and approaching solutions to environmental problems.

Question 3

What was the intent of this question?

The intent of this question was for students to evaluate uses and alternate disposal methods for solid waste in the United States. Information on municipal solid waste (MSW) produced in the United States from 1960 to 2012 was presented in graphical form: two lines on the same graph, one describing Total MSW created and the other describing the Per Capita MSW created. In part (a) students were asked to explain the change (decline) in per capita MSW as depicted in the graph and calculate the percent increase in total MSW from 2000 to 2012.

In part (b) students were asked to identify a disadvantage of waste incineration and waste disposal in landfills. In part (c) students were asked to describe how electricity can be generated from waste buried in a landfill. The correct description included a methane capture step, a heat to steam or hot air step and then a turbine/generator spin step. The steps were not linked and therefore a student could earn one, two, or all three points in this part. Part (d) required students to identify human health problems that may result from piles of discarded tires. Finally in part (e) students were asked to identify an advantage and a disadvantage of composting.

How well did students perform on this question?

The mean score was 3.35 out of a possible 10 points.

What were common student errors or omissions?

In general, only the commercial incineration or disposal of waste were considered when creating the rubric for question 3 as the stem of the question clearly defines municipal solid waste (MSW) as the trash collected from homes and businesses. Therefore no responses with backyard disposal or incineration of MSW were considered when constructing the question 3 rubric.

In part (a)(i) a few students read the wrong line on the graph and described a slight increase in Per Capita MSW Generation or ascribed the decline on the correct line on the graph to an increase in population of the United States. Since describing an amount produced as Per Capita normalizes the data, it is not correct to give population increase as the cause for the change.

In part (a)(ii) a few students constructed the percent change fraction incorrectly by placing the final value in the denominator and yielding an increase of 40 percent. A few students expressed their answer as a rate and divided by twelve years. Some students obtained the correct answer by dividing final by initial and then subtracting one from this improper fraction to yield the correct answer. Some students neglected this final step and identified 166 percent as the percent increase.

In part (b)(i) many students identified the production of air pollution as a disadvantage of waste incineration but then neglected to state a specific, correct air pollutant. The students must be able to identify a specific, correct air pollutant to earn this point.

In part (c) a few students incorrectly stated that the waste buried in the landfill would be exhumed and used as a fuel source in the fuel collection step. A few students' descriptions did not include the creation of steam or hot air in the combustion step. A few students' description did not mention spinning, turning or rotating the turbine or generator. The question 3 rubric is very specific about what comprises a true description of electricity generated from waste buried in a landfill.

Part (d) proved to be the most difficult section of question 3 for students to earn a point. However, many students earned a point for describing either diseases spread by pests (mosquitoes, rats, etc.) that reside or breed in tire piles or the respiratory issues that may result from the burning of tires. Runoff from tire piles and direct (without combustion) air pollution from tire piles were not accepted.

In (e)(i) many students clearly understood the purpose of composting to yield either fertilizer or nutrient-rich soil and earned this point. However, many students responded as if composting was an alternative to incineration or landfilling of all MSW rather than for certain materials only.

In (e)(ii) a few students identified the time necessary for the organic material to decompose as a disadvantage rather than the time and labor invested by the human composter.

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:

- Students should be reminded repeatedly that the responses they write must have the requisite depth to earn the points intended.
- Students must practice the type of calculations that occur on the AP Environmental Science exam. A percentage change was requested on question 3. Students should be capable of performing this simple calculation without calculators.
- Students should be encouraged to show the work that leads to their answer in part (a)(ii). Although certain students may be capable of calculating a correct answer in their heads, they must show their work to earn the point.
- Students should be reminded about the different levels of verbal requests, i.e., identify, describe, explain, and discuss. Identify may be the simplest of these verbs, but it still requires some detail to satisfy the request as presented.
- In part (c) some students did not describe the specific steps in electricity generation. "Specific steps" means discrete, sequential steps from a defined beginning point to a defined end point.
- Students should demonstrate what they have learned in their AP Environmental Science class through proper use of terminology, for instance, properly using terms like "infiltrate" or "leachate" in part (a)(ii).
- Students should be reminded that when one cause or one advantage is asked for, only the first response will be graded. Students may make a list of answer possibilities in the question margin from which they may then choose one response that best satisfies the question request.

Question 4

What was the intent of this question?

The intent of this question was for students to identify and describe factors that influence soil formation, degradation, and soil quality. In part (a) students were asked to describe two climate factors that could affect the rate of soil formation. In part (b) students were asked to apply their knowledge of various soil horizons, and identify a specific biotic and an abiotic component of the A horizon. In part (c) students were asked to identify one agricultural practice that could lead to elevated nitrate levels in groundwater, and apply their knowledge of groundwater recharge to describe how this agricultural practice could elevate nitrate levels in groundwater. Acid deposition can affect soil quality. In part (d) students were asked to explain how acid deposition onto soil can affect plant health and to describe one method for remediating soil affected by acid deposition. Climate change has caused far-reaching ecosystems changes, which include soil degradation. In part (e) students were asked to describe two ways in which climate change could degrade soil.

How well did students perform on this question?

The mean score was 2.78 out of a possible 10 points.

What were common student errors or omissions?

In part (a) common errors included students identifying a climate factor, rather than describing how that factor influenced the rate of soil formation. Students incorrectly related climate factors to plant growth, rather than soil formation. Additionally, they frequently indicated that a climate factor would affect the rate of soil formation without indicating if that factor sped up or slowed down the rate of formation.

In part (b) although many students correctly identified a specific biotic and abiotic component of the A horizon, some students did not differentiate between biotic and abiotic components of the A horizon. Students incorrectly identified loam (a soil texture) as a component of the A horizon.

In part (c)(i) many students correctly identified fertilizing crops as an agricultural practice that can lead to elevated nitrate levels in ground water. Although this was not the only correct answer, it was the correct answer chosen by the majority of the students who earned credit on this part of the question. Students did not earn credit in part (c)(ii) for indicating that nitrates were carried as runoff into surface waters or for describing that nitrates, through runoff, flowed into ground water.

In part (d)(i) common errors included identifying an impact of acid deposition instead of explaining the impact of acid deposition onto soil and the subsequent impact on the health of the plants. Students did not earn credit for stating that plants die because the soil is too acidic. In (d)(ii), many students correctly described adding limestone/lime/calcium carbonate as a method to decrease the acidity of the soil. Students did not earn credit for merely adding a base or an alkaline as a method to decrease the acidity of the soil.

In part (e) students incorrectly identified acid rain as a consequence of climate change. Students did not earn credit for merely stating a weather phenomenon. For example, stating that droughts causes the soil to dry out, rather than describing climate change phenomenon that could lead to drought, did not earn a point. Students incorrectly described how climate change degraded plant growth rather than how climate change degraded soil.

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 phrases such as "it's bad."
- Review how natural climate factors influence rates of soil formation and the characteristics of soil horizons.
- Help students understand the difference between runoff onto surface waters and percolation/infiltration of water into aquifers/groundwater.
- Remind students that even if topics, such as fertilizers and pesticides, are covered in the same chapter, they can have different impacts on components of the environment.
- Review how climate change has impacted such factors as precipitation and temperature and how changes in those factors can directly lead to soil degradation.
- Apply concepts learned in class to real life examples. For example, how has climate change impacted soil in coastal areas or how has fertilizer use impacted groundwater quality.
- Provide students with multiple opportunities to answer and peer grade free-response questions.