

# AP<sup>®</sup> STATISTICS

## 2013 SCORING GUIDELINES

### Question 2

#### **Intent of Question**

The primary goals of this question were to assess a student's ability to (1) recognize and explain why a particular sampling method is likely to be biased; (2) describe a method for selecting a simple random sample from a population using a computer random number generator; and (3) demonstrate an understanding of the principle of stratification by describing circumstances in which one stratification variable would be better than another.

#### **Solution**

##### **Part (a):**

The first 500 students who enter the football stadium were not likely to be representative of the population of all students at the university. In other words, these 500 students were likely to differ systematically from the population with regard to many variables. For example, these 500 students might have more school pride than the population of students as a whole, which might be related to their opinions about the appearance of university buildings and grounds. Perhaps their school pride is related to having more positive opinions about the appearance of university buildings and grounds, in which case the sample proportion of students who were satisfied would be biased toward overestimating the population proportion of students who were satisfied.

##### **Part (b):**

Obtain a list of all 70,000 students at the university. Assign an identification number from 1 to 70,000 to each student.

Then use a computer to generate 500 random integers between 1 and 70,000 without replacement. The students whose ID numbers correspond to those numbers were then selected for the sample.

##### **Part (c):**

Stratifying by campus would be more advantageous than stratifying by gender provided that opinions about appearance of university buildings and grounds between the two campuses differ more than the opinions about appearance of university buildings and grounds between the two genders.

#### **Scoring**

Parts (a), (b), and (c) were scored as essentially correct (E), partially correct (P), or incorrect (I).

**Part (a)** is scored as follows:

Essentially correct (E) if the response correctly includes the following three components:

1. Provides a reasonable explanation for why the sample might not be representative of the population;
2. Mentions a link between the nonrepresentative nature of the convenience sample and the variable of interest (opinion about appearance of university buildings and grounds);

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### Question 2 (continued)

3. Indicates a plausible direction for the bias of the estimator by:
- Explicitly identifying the direction of the bias in the estimate of the population proportion of students satisfied with the appearance of the buildings and grounds,  
*OR*
  - Stating or implying that the students in the sample were more (or less) likely to be satisfied with the appearance of the buildings and grounds than those not in the sample.

Partially correct (P) if the response correctly provides exactly two of the three components listed above.

Incorrect (I) if the response correctly provides one or none of the three components listed above.

**Part (b)** is scored as follows:

Essentially correct (E) if the response correctly includes the following three components:

1. Assigns numbers to the student names;
2. Uses a computer random number generator to randomly generate 500 distinct/unique numbers between 1 and 70,000;
3. Selects students whose names correspond to the 500 random numbers for the sample.

Partially correct (P) if the response correctly includes two of the three components listed above (with the exception of the second reason given for an (I) below).

Incorrect (I) if the response correctly includes no more than one of these three components;  
*OR*

if the response proposes implementing a sampling method other than simple random sampling (for example, systematic sampling).

**Part (c)** is scored as follows:

Essentially correct (E) if the response correctly notes that the circumstance described requires more variability in opinions about appearance of university buildings and grounds between the two campuses than between the two genders.

Partially correct (P) if the response says that the circumstance described requires considerable variability in opinions about appearance of university buildings and grounds between the two campuses without explicitly comparing to variability between the two genders,  
*OR*

if the response only says that the circumstance described requires more variability between the two campuses than between the two genders without referring to opinions about appearance of university buildings and grounds,  
*OR*

if the response notes that the circumstance described requires homogeneity of opinions about appearance of university buildings and grounds within the two campuses.

Incorrect (I) if the response does not meet the criteria for E or P.

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**Question 2 (continued)**

**4 Complete Response**

All three parts essentially correct

**3 Substantial Response**

Two parts essentially correct and one part partially correct

**2 Developing Response**

Two parts essentially correct and one part incorrect

*OR*

One part essentially correct and one or two parts partially correct

*OR*

Three parts partially correct

**1 Minimal Response**

One part essentially correct and two parts incorrect

*OR*

Two parts partially correct and one part incorrect

2. An administrator at a large university wants to conduct a survey to estimate the proportion of students who are satisfied with the appearance of the university buildings and grounds. The administrator is considering three methods of obtaining a sample of 500 students from the 70,000 students at the university.
- (a) Because of financial constraints, the first method the administrator is considering consists of taking a convenience sample to keep the expenses low. A very large number of students will attend the first football game of the season, and the first 500 students who enter the football stadium could be used as a sample. Why might such a sampling method be biased in producing an estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds?

The first people to arrive at the football game are likely to be zealous fans of the school, and will probably give a higher proportion of satisfaction than a truly random sample of students.

- (b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

Arrange the students in a list alphabetically by last name. Then assign each student a number such that the first student is 1 and last is 70,000. Use a random number generator to select random numbers between 1 and 70,000, selecting the student who corresponds to each number. Repeated numbers should be ignored. Continue this process until 500 unique numbers (and thus students) have been chosen.

2A2

- (c) Because stratification can often provide a more precise estimate than a simple random sample, the third method the administrator is considering consists of selecting a stratified random sample of 500 students. The university has two campuses with male and female students at each campus. Under what circumstance(s) would stratification by campus provide a more precise estimate of the proportion of students who are satisfied with the appearance of the university buildings and grounds than stratification by gender?

Stratification by campus would be more precise if the two campuses varied a great deal in appearance or age, as these two attributes would affect student satisfaction more than minute differences in opinion related to gender.

2. An administrator at a large university wants to conduct a survey to estimate the proportion of students who are satisfied with the appearance of the university buildings and grounds. The administrator is considering three methods of obtaining a sample of 500 students from the 70,000 students at the university.
- (a) Because of financial constraints, the first method the administrator is considering consists of taking a convenience sample to keep the expenses low. A very large number of students will attend the first football game of the season, and the first 500 students who enter the football stadium could be used as a sample. Why might such a sampling method be biased in producing an estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds?

This sampling method would be biased because students who enjoy attending football games may have a more satisfied perspective of the buildings and grounds, since they enjoy going out onto the grounds for the football game, and this satisfied perspective may be especially abundant in those attending the football game causing an inaccurate portrayal of the overall student population's opinion.

- (b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

Get an alphabetical list of all the students and assign each individual a number, 1-70,000. Then use a random number generator to select 500 numbers, disregarding repeats, and use the people whose names correspond with the 500 numbers selected to participate in the study.

2B2

- (c) Because stratification can often provide a more precise estimate than a simple random sample, the third method the administrator is considering consists of selecting a stratified random sample of 500 students. The university has two campuses with male and female students at each campus. Under what circumstance(s) would stratification by campus provide a more precise estimate of the proportion of students who are satisfied with the appearance of the university buildings and grounds than stratification by gender?

If student satisfaction is generally the same regardless of gender for the campus and the two campuses were very different from one another, <sup>having different designs or one was newer or nicer than the other,</sup> stratification by campus would provide a more precise estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds than stratification by gender.

2. An administrator at a large university wants to conduct a survey to estimate the proportion of students who are satisfied with the appearance of the university buildings and grounds. The administrator is considering three methods of obtaining a sample of 500 students from the 70,000 students at the university.

- (a) Because of financial constraints, the first method the administrator is considering consists of taking a convenience sample to keep the expenses low. A very large number of students will attend the first football game of the season, and the first 500 students who enter the football stadium could be used as a sample. Why might such a sampling method be biased in producing an estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds?

Therefore  
 This could be biased because the students who are attending the football game are obviously very proud of their school and support their team and school. These students most likely will not have a problem with their school's appearance because they're so proud of the school itself and what it stands for.

- (b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

First each student should be assigned a number that falls between 00000 and 69,999. Now all 70,000 students have a number assigned to them. Then use a computer to generate a random digits table and pick out the first 500 numbers that fall between 00000 and 69,999. When you have your 500 numbers, correspond the correct number to the correct student and you have a sample of 500 random students.



- (c) Because stratification can often provide a more precise estimate than a simple random sample, the third method the administrator is considering consists of selecting a stratified random sample of 500 students. The university has two campuses with male and female students at each campus. Under what circumstance(s) would stratification by campus provide a more precise estimate of the proportion of students who are satisfied with the appearance of the university buildings and grounds than stratification by gender?

Stratification by campus would give a more precise estimate than gender because if one campus is nicer than another, that proportion will obviously be more satisfied with the appearance of the university, compared to the less appealing campus.

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## 2013 SCORING COMMENTARY

### Question 2

#### Overview

The primary goals of this question were to assess a student's ability to (1) recognize and explain why a particular sampling method is likely to be biased; (2) describe a method for selecting a simple random sample from a population using a computer random number generator; and (3) demonstrate an understanding of the principle of stratification by describing circumstances in which one stratification variable would be better than another.

#### Sample: 2A

##### Score: 4

In part (a) the student states that a characteristic that might make the sample unrepresentative of the population is that the members of the sample are "likely to be zealous fans of the school," which satisfies the first component. The student then writes that such a sample "will probably give a higher proportion of satisfaction," which gives a link to the variable and indicates a positive bias in the estimator. Because the student has all three required components, part (a) was scored as essentially correct. In part (b) the first component is satisfied by assigning "each student a number such that the first student is 1 and the last is 70,000." Then the student describes using a random number generator to select random numbers between 1 and 70,000, ignoring repeats, until 500 unique numbers are obtained. Thus the second component is satisfied. The student associates these numbers with students (the third component) twice, once when writing "selecting the student who corresponds to each number" and again when writing "until 500 unique numbers (and thus students) have been chosen." Because the student had all three required components, part (b) was scored as essentially correct. In part (c), in saying "the two campuses varied a great deal in appearance or age as these two attributes would affect student satisfaction more than minute differences in opinion related to gender," the student clearly compares the variability in the responses between campuses and genders, correctly indicating that the circumstance requiring the given stratification is one in which there is greater variability in the opinions between campuses than between genders. This brief and to-the-point description shows that the student understands when the use of stratification is warranted, so part (c) was scored as essentially correct. Because all three parts were scored as essentially correct, the response earned a score of 4.

#### Sample: 2B

##### Score: 3

In part (a) the response states that the characteristic that makes the first 500 students at the football game different from the rest of the students is that they "enjoy going out onto the grounds for the football game." This is sufficient to satisfy the first component. Twice in the response, there is linkage between the students in the sample and having a "satisfied perspective," which satisfies the second component. Finally, the student shows that there is a positive bias by writing that the members of the convenience sample "have a more satisfied perspective" or "this satisfied perspective may be especially abundant in those attending;" either would be sufficient to satisfy the third component. Because the student has all three components correct, part (a) was scored as essentially correct. In part (b) the response correctly assigns numbers to the students, satisfying the first component. The student then says to use a random number generator to select 500 numbers ignoring repeats, but does not say to select values between 1 and 70,000. Thus the second component is not satisfied. The response does say to "use the people whose numbers correspond with the 500 numbers," satisfying the third component. With two of the three components satisfied, part (b) was scored as partially correct.

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**Question 2 (continued)**

In part (c) the student writes “If student satisfaction is generally the same regardless of gender for the campus and the two campuses were very different from one another,” indicating that stratification would be useful if there is more variability in opinions between the campuses than between the genders. The response shows an understanding of when to use stratification, so part (c) was scored as essentially correct. Because two parts were scored as essentially correct and one part was scored as partially correct, the response earned a score of 3.

**Sample: 2C**  
**Score: 2**

In part (a) the response describes the students as being “obviously very proud of their school and therefore support their team and school,” satisfying the first component. Continuing with the 500 students, the response says that they “most likely will not have a problem with their school’s appearance,” satisfying the second component. Unfortunately the response lacks a strong indication of the direction of the bias. The closest the response comes to identifying the direction of the bias is when it states that the sample “most likely” will not have a problem. However, it is certainly possible that the rest of the population “most likely” will not have a problem with the appearance either. To satisfy the third component, the response would need a clearer comparison, such as saying that the sample is more likely to not have a problem with the appearance than the students not in the sample. With two components satisfied, part (a) was scored as partially correct. In part (b) the student correctly begins by saying “each student should be assigned a number that falls between 00000 and 69,999,” satisfying the first component. The response then says to “use a computer to generate a random digits table and pick out the first 500 numbers that fall between 00000 and 69,999.” It is legitimate to create a random number table from the random numbers generated by the computer, even if this is an unnecessary step. However, the student does not address what to do when a repeated number is obtained and did not satisfy the second component. The student satisfied the third component by writing “When you have your 500 numbers, correspond the correct number to the correct student and you have a sample of 500 random students.” With two components satisfied, part (b) was scored as partially correct. In part (c) the response implies that there is variability in opinions on the appearance of the campuses by writing “if one campus is nicer than another, that proportion will obviously be more satisfied with the appearance of the university compared to the less appealing campus.” However, the response does not compare this variability between campuses to the variability that might be found between the opinions of the two genders, which could be even larger. So part (c) was scored as partially correct. Because three parts were scored as partially correct, the response earned a score of 2.