AP® STATISTICS
2011 SCORING GUIDELINES (Form B)

Question 4

Intent of Question

The primary goals of this question were to assess students' ability to (1) specify hypotheses for the chi-square test of independence; (2) state and check the appropriate conditions for inference; (3) interpret standard statistical output; (4) identify and describe the type of error that could have been made.

Solution

Part (a):

H_0 : There is no association between perceived effect of part-time work on academic achievement and average time spent on part-time jobs.
H_a : There is an association between perceived effect of part-time work on academic achievement and average time spent on part-time jobs.

Part (b):

The following conditions for inference are met:
1. The students were randomly selected.
2. The expected cell counts should be at least 5. The computer output indicates that all expected counts are greater than 5. The smallest expected cell count is 6.825.

Part (c):

Because the *p*-value 0.007 is less than 0.05, H_0 should be rejected. There is convincing evidence that there is an association between the perceived effect of part-time work on academic achievement and average time spent on part-time jobs.

Part (d):

Because the null hypothesis was rejected, a Type I error may have been made. A Type I error is concluding that there is an association between the perceived effect of part-time work on academic achievement and the average time spent on part-time jobs when, in reality, there is no association between the two variables.

Scoring

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

Part (a) is scored as follows:

Essentially correct (E) if the response includes the following three components:
1. The statement of no association (or independence) is in the null hypothesis, and the statement of association (or dependence) is in the alternative hypothesis.
2. The hypotheses do not imply a cause-and-effect relationship.
3. Acceptable terms are used for the two variables in the hypotheses.

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Question 4 (continued)

Partially correct (P) if the response includes exactly two of the three components above.

Incorrect (I) if the response fails to meet the criteria for E or P.

Part (b) is scored as follows:

Essentially correct (E) if the response includes *BOTH* conditions necessary for the test and indicates that *BOTH* conditions are met for these data.

Partially correct (P) if only one of the necessary conditions is included *AND* the response indicates that the condition is met for these data, *OR* both conditions are stated, *BUT* the response does not indicate that the conditions are met for these data.

Incorrect (I) if response fails to meet the criteria for E or P.

Note: If the response also includes conditions that are not required for the chi-square test, the response should be scored no higher than P for this part.

Part (c) is scored as follows:

Essentially correct (E) if the response includes a correct conclusion, in context, *AND* provides a justification based on linkage between the *p*-value and the conclusion.

Partially correct (P) if the response includes a correct conclusion, with linkage to the *p*-value, *BUT* the conclusion is not in context, *OR* the response includes a correct conclusion, in context, *BUT* linkage to the *p*-value is missing.

Incorrect (I) if response fails to meet the criteria for E or P.

Notes

- The conclusion should be scored based on the hypotheses given in the response to part (a).
- If both an α and a *p*-value are given together, the linkage between the *p*-value and the conclusion is implied. If no α is given, the solution must be explicit about the linkage by giving a correct interpretation of the *p*-value or explaining how the conclusion follows from the size of the *p*-value.
- A response that reaches a cause-and-effect conclusion cannot earn an E, unless this was already penalized in part (a). A response that includes a cause-and-effect conclusion should be scored as P, provided that the conclusion is in context and there is linkage to the *p*-value. It should be scored as I if it lacks either context or linkage to the *p*-value.

Part (d) is scored as follows:

Essentially correct (E) if a Type I error is identified and described in the context of the question.

Partially correct (P) if a Type I error is identified and a generic description of a Type I error, without context, is provided, *OR* correct statements are provided, in context, with an incorrect error name (Type II error).

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Question 4 (continued)

Incorrect (I) if a Type II error is described, *OR* no description or an incorrect description is provided.

Note: Part (d) should be scored based on the hypotheses given in the response to part (a) and the conclusion in part (c).

Each essentially correct (E) part counts as 1 point. Each partially correct (P) part counts as ½ point.

4 **Complete Response**

3 **Substantial Response**

2 **Developing Response**

1 **Minimal Response**

If a response is between two scores (for example, 2½ points), use a holistic approach to decide whether to score up or down, depending on the overall strength of the response and communication.

4A

4A

(a) State the null and alternative hypotheses for this test.

Null Hypothesis (H_0) = There is no association between the effect of part-time work on academic achievement and the average number of hours per week that students work.

Alternate Hypothesis (H_a) = There is an association between the effect of part-time work on academic achievement and the average number of hours per week that students work.

(b) Discuss whether the conditions for a chi-square inference procedure are met for these data.

* All expected counts are greater than 5 (Met - Shown in two-way table)
* Independent simple Random samples (Met - Given).
* Large Population ≥ 30

(c) Given the results from the chi-square test, what should the advisory board conclude?

Because the pvalue = 0.007 < α=0.05 (significance level), there is enough evidence to reject the null hypothesis. There is sufficient evidence to support the conclusion that there is an association between the effect of part-time work on academic achievement and the average number of hours per week that students work.

(d) Based on your conclusion in part (c), which type of error (Type I or Type II) might the advisory board have made? Describe this error in the context of the question.

The advisory board may have made a Type I error, which is rejecting the null hypothesis when it is true. The advisory board could have come to the conclusion that there is an association between the effect of part time work on academic achievement and the average number of hours per week that students work when there actually isn't.

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4B

4B

(a) State the null and alternative hypotheses for this test.

H_0: There is an association between the effect of part-time work on academic achievement and the average number of hour per week that students work

H_a: There is no association (The effect and number of hours are independent)

(b) Discuss whether the conditions for a chi-square inference procedure are met for these data.

We have quite appropriate sample.
All expected values are equal or bigger than 5.
We have two variables, for which we are making chi-square test.

(c) Given the results from the chi-square test, what should the advisory board conclude?

Since the p-value is very small ($0.007 < 0.05$, $0.007 < 0.01$)
I can reject the null, so I can say that there is no association between number of hours spent on work and effect on academic achievement

(d) Based on your conclusion in part (c), which type of error (Type I or Type II) might the advisory board have made? Describe this error in the context of the question.

	reject	fail
H_0 true	I-type	
H_a true	P (power of the test)	II-type

I could made an I-type error. Since I rejected true null hypothesis, which might be true.

There are might be association between number of hours student work and effect on academic achievements, but because we rejected the null we could reject the true thing that there is an association, and might accept alternative hypothesis, that there is no associations.

4C

4C

(a) State the null and alternative hypotheses for this test.

null hypothese H_0: ~~part~~ Part-time jobs have no effect on the academic achievement of students attending the university

alternative hypothese H_1: Part-time jobs have effect on the academic achievement of students attending the universit

(b) Discuss whether the conditions for a chi-square inference procedure are met for these data.

$n = 200 > 5$, so the sample size is large enough

The results of survey are independent from each other.

All the conditions for a chi-square inference procedure are met.

The survey can be taken for n times.

(c) Given the results from the chi-square test, what should the advisory board conclude?

since P-Value = 0.007 ~~= 0.0~~ $< \alpha$ whenever $\alpha = 0.01, 0.05$ or 0.1, we have evidence to reject the null hypothese, in other words, part-time jobs ~~or~~ have effect on the academic achievement of students attending the university

(d) Based on your conclusion in part (c), which type of error (Type I or Type II) might the advisory board have made? Describe this error in the context of the question.

~~Type II might the~~

The advisory board ~~may~~ might have made ~~a~~ type I error, since the null hypothese is rejected.

This error means that part-time jobs have no effect on the academic achievement of students attending the university, but the advisory board said that ~~it has effect~~ the effect ~~on~~ of part-time jobs on academic achievement ~~or~~ exists.

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AP® STATISTICS
2011 SCORING COMMENTARY (Form B)

Question 4

Sample: 4A
Score: 4

In part (a) correct hypotheses are given, and correct variable names are used. Part (a) was scored as essentially correct. Both of the required conditions are addressed in part (b). The statement "Large population ≥ 30" was viewed as extraneous, but not incorrect, information. Part (b) was scored as essentially correct. A correct conclusion, in context, is provided in part (c), and the conclusion is linked to the given p-value. Part (c) was scored as essentially correct. A Type I error is identified in part (d), and the response includes a correct description of a Type I error, in context. Part (d) was scored as essentially correct. Because four parts were scored as essentially correct, the response earned a score of 4.

Sample: 4B
Score: 3

Although acceptable variable names are used in part (a), "no association" appears in the alternative hypothesis rather than the null hypothesis. Because the null and alternative hypotheses are reversed, part (a) was scored as partially correct. In part (b) the sample-size requirement that all expected counts be greater than or equal to 5 is addressed, but the statement that "[w]e have quite appropriate sample" is not adequate for the random sample condition. For this reason, part (b) was scored as partially correct. Part (c) includes a conclusion that is consistent with the hypotheses given in part (a), and the conclusion is linked to the given p-value. Part (c) was scored as essentially correct. A Type I error is identified in part (d), and a description of a Type I error that is consistent with the hypotheses given in part (a) is provided, in context. Part (d) was scored as essentially correct. Because two parts were scored as essentially correct and two parts were scored as partially correct, the response earned a score of 3.

Sample: 4C
Score: 2

The response to part (a) contains two common errors. The hypotheses are worded in a way that implies a cause-and-effect relationship between the two variables of interest, and incorrect variable names are used. Because of these errors, part (a) was scored as incorrect. Part (b) was also scored as incorrect because neither of the two required conditions are adequately addressed. A conclusion linked to the given p-value is included in part (c). Although it is incorrect to draw a cause-and-effect conclusion based on the study designed and the test performed, this error was overlooked in part (c) because it had already been penalized in the scoring of part (a). Part (c) was therefore scored as essentially correct. A Type I error is correctly identified in part (d), and a description of the error is given, in context. As with part (c), the error of making a cause-and-effect statement in this setting was overlooked here. Part (d) was scored as essentially correct. Because two parts were scored as essentially correct and two parts were scored as incorrect, the response earned a score of 2.