Reviewing the 2014 AP Statistics Exam

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Our Goals for Today...

- Review the questions from 2014 exam
- Discuss rubrics
- What are common student misconceptions
- Your questions about grading the exam
2014 FRQ Overview

**Context of Question:**
Q1: Residential Status & Extracurricular Activities
Q2: Attending a convention
Q3: School funding/attendance
Q4: Class reunion & income
Q5: Price of automobiles for men & women
Q6: Cars - fuel, engines, & wheel

**Content of Question:**
Q1: Two-way tables, segmented bar graph, hyp. test conclusion
Q2: Prob. & randomness, simulation
Q3: Normal & samp. distributions
Q4: Mean v. Med, sampling issues
Q5: Matched pairs t-test
Q6: Linear Regression, residuals
Q1: Residents & Extracurriculars

Goals of the Question:
● calculate conditional proportions from a two-way table
● comment on association between two categorical variables as displayed in a graph
● draw an appropriate conclusion from the p-value of a chi-square test.

Avg: 1.96      SD: 1.08
Q1: Common Errors

Part (a)
- Students(S) gave proportions for \textit{only 1 activity} instead of \textit{at least 1 activity}

Part (b)
- S described distributions without \textit{comparative} language
- S described using comparative language but no \textit{context}
- S focused on \textit{counts} instead of \textit{proportions}

Part (c)
- S \textit{accepted the null hypothesis!}
- Lack of \textit{context}
Q1: Teacher Recommendations

What can we do:

- frequently remind students that they must show work behind numerical calculations
- provide many opportunities for students to write paragraphs comparing the distributions of *categorical variables* between two (or more) groups
- emphasize to students the importance of proportional reasoning, *using proportions rather than counts* to make comparisons between groups
- make clear to students the distinction between *accepting a null hypothesis and failing to reject a null hypothesis*
  - Failing to reject: “*which gives no evidence of an association*”
  - Accepting the null: “*which gives evidence of no association*”
Q2: Attending a Convention

Goals of the Question:

- calculate a probability
- assess whether a claim about randomness is questionable in light of a calculated probability
- determine whether a description of a simulation method achieves a correct simulation of a random process

Avg: 1.61    SD: 1.36
Q2: Common Errors

Part (a)
- S calculated probability as if sampling *with replacement* was done

Part (b)
- S did not justify their conclusion by describing the probability as small or by comparing the probability to a common significance level (5 or 10%)
- S ignored the probability by arguing that selecting all women is possible with random selection, so there is no reason to doubt the manager’s claim about random selection

Part (c)
- Many students did not notice that the simulation method described is only appropriate for sampling with replacement and so mistakenly replied that the simulation method is reasonable
Q2: Teacher Recommendations

What can we do:

- provide students with opportunities to calculate probabilities in situations where sampling is conducted *without replacement*
- expose students to probability questions in *realistic situations* rather than solely abstract ones involving dice and cards
- emphasize to students the logical reasoning process behind the argument with a small probability for a particular model/assumption/hypothesis, then the occurrence of that observed result provides strong evidence against that model/assumption/hypothesis
- resist the temptation to force students to follow a fill-in-the-blanks template for such arguments
- conduct simulations involving both sampling with and without replacement
Q3: School Funding & Attendance

Goals of the Question:

- perform a probability calculation from a normal distribution
- explain an implication of examining the distribution of a sample mean rather than the distribution of a single measurement
- perform a probability calculation involving independent events using the multiplication rule

Avg: 1.43  SD: 1.10
Q3: Common Errors

Part (a)
- S did not clearly state that they were using a normal distribution, either with the word “normal” or with a clearly labeled sketch.
- Parameters (mean and std. dev.) not identified
- Subtraction in wrong order

Part (b)
- S did not answer question or provide justification
- S argued since the sample size was under 30, they couldn’t calculate

Part (c)
- S mistakenly applied the complement rule, calculating the probability that none of the events would occur as one minus the probability that all of the events would occur.
What can we do:

- when working with probability distributions, they should clearly state the name of the probability distribution and clearly identify its parameter values
  - grade student work carefully to encourage clear communication
- for questions with normal distributions - draw a well-labeled sketch that identifies the parameter values and shades in the region whose probability is being calculated
- insist that students answer the question asked, especially when the question asks about which of three options (ex: more likely, less likely, or equally likely)
- understand the fundamental distinction between the distribution of a population and the sampling distribution of a statistic such as a sample mean
Q3: Teacher Recommendations

What can we do:

- emphasize to students that the standard deviation of a sample mean is the population standard deviation divided by the sample size, regardless of how large the sample size is and even regardless of the shape of the population distribution.
- always ask whether their answer to a probability question seems reasonable, especially to question probability calculations that result in an answer larger than one!
Q4: Class Reunion & Incomes

Goals of the Question:

- describe why the median might be preferred to the mean in a particular context
- compare the relative merits of two sampling plans
- describe a consequence of nonresponse in a particular study

Avg: 1.79    SD: 1.16
Q4: Common Errors

Part (a)

- Many students exhibited inaccuracy with their use of statistical terms, for example by writing that outliers skew the mean or that means are biased when there is skewness.
- S gave generic statements about how outliers or skewness affect the mean and do not affect the median, without making the connection to *incomes* *(context)*

Part (b)

- Many students gave good arguments for weaknesses of Method 1 but did not specify advantages of Method 2.
- Many students did not describe the effect of the bias in Method 1 on the sample mean, even though the question specifically asked for this.
Q4: Common Errors

Part (b)

- Many students used the ambiguous statement that “results will be more accurate” when commenting on Method 2’s effect on the estimate.
- Some students chose Method 1 based on the larger sample size, ignoring or dismissing issues of sampling bias.
- Some students did not explicitly choose one of the methods.
Q4: Teacher Recommendations

What can we do:

- Remember **context**!
- Justify their choice especially when asked for a choice between options!
- Reinforce **vocabulary**
  - bias vs. skew
  - mean vs. median (related to shape of distribution)
- Emphasize the understanding of phenomena such as nonresponse bias, perhaps concentrating less on the names of such phenomena
  - What is the result of nonresponse bias
- Present students with examples where a larger sample size is not necessarily better
Q5: Car Prices - Men vs. Women

Goals of the Question:

- state appropriate hypotheses
- identify the appropriate statistical test procedure and check appropriate conditions for inference
- calculate the appropriate test statistic and p-value
- draw an appropriate conclusion, with justification, in the context of the study.

Avg: 1.10  SD: 1.20
Q5: Common Errors

- S did not realize that this question called for a *hypothesis test*
- *Paired v. two-sample t test*
- Parameters defined incorrectly
- Why are conditions used?
- Used a z-test (without a pop. standard deviation)
- S still created graphs despite all information was given in the question
- *Accepted the null hypothesis*
- Lack of communication (4-step process)
Q5: Teacher Recommendations

What can we do:

- recognize that “data provide convincing evidence” calls for a hyp. test
- provide many, many opportunities for students to identify the appropriate inference technique to apply to a particular research question
  - included paired vs. two-sample t test situations
- encourage students to follow the **four steps in the scoring guidelines**
- use **t-procedures** instead of z-procedures for quantitative data
- provide unnecessary information (graphs, statistics) to give students practice with identifying what is relevant
- recognizing that identifying parameters is a **challenging task** for many students, teachers should provide considerable experience and feedback with this aspect of hypothesis testing
- **NEVER ACCEPT THE NULL!**
Q6: Cars - fuel, engines, & wheel

Goals of the question:

- calculate and interpret a residual value
- answer questions about residual plots
- compare associations between two scatterplots
- identify an appropriate explanatory variable to include in a regression model based on residuals from simpler regression models.

Avg: 1.29  SD: 0.99
Q6: Common Errors

Parts (a-b)
- Some students interpreted the residual in terms of distance from the predicted FCR but did not indicate *direction or magnitude*.
- Most students failed to realize that the residual was based on a regression model with length.

Parts (c-d)
- S described the association in each scatterplot but neglected to compare them with clearly comparative language.
- Misinterpreting the residuals, invariably led students to incorrectly select wheel base as the additional variable to include in a regression model.
Q6: Teacher Recommendations

What can we do:

- interpreting residuals requires commenting on both magnitude and direction
- residuals represent the unexplained variability in a statistical model, and a common goal is to reduce/explain as much of the variability as possible
- the investigate task often begins with questions for which fairly standard tools are appropriate but then often asks a question or two that requires students to extend their knowledge in a new way
- sound advice for all questions, but especially for investigative tasks, is to always read questions carefully and respond to exactly what is asked
Sources:


