Calculations Aren't Enough!

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The Importance of Communication in AP Statistics

Statistics differs from mathematics in a number of fundamental ways. The primary purpose of statistics is to provide analysts and researchers with methods for collecting data in a reasonable way and for making sense out of that data. As such, context is critical to statistics and helps distinguish it from mathematics. Although data are often numerical, authors George Cobb and David Moore remind us that "data are not just numbers, they are numbers with a context."

Cobb and Moore also state:

> Although mathematicians often rely on applied context both for motivation and as a source of problems for research, the ultimate focus in mathematical thinking is on abstract patterns: the context is part of the irrelevant detail that must be boiled off over the flame of abstraction in order to reveal the previously hidden crystal of pure structure. In mathematics, context obscures structure. Like mathematicians, data analysts also look for patterns, but ultimately, in data analysis, whether the patterns have meaning, and whether they have any value, depends on how the threads of those patterns interweave with the complementary threads of the story line. In data analysis, context provides meaning.

This difference is the main reason that communication is such an important aspect of statistics problems. In statistics, meaning comes from context, and the interpretation of the analysis in context is the ultimate desired outcome of analyzing data.

A look at how the free response questions on the AP Statistics Exam are scored shows that both statistical knowledge and communication are important. The Teacher's Guide for AP Statistics (1997) identifies five different levels for each of these two areas for scoring open-ended statistics questions. For communication -- the explanation of what was done and why and the interpretation of results in context -- these levels are listed below:

Highest	○ Provides a clear, organized, and complete explanation, using correct terminology, of what was done and why ○ States appropriate assumptions and caveats ○ Uses diagrams or plots when appropriate to aid in describing the solution ○ States an appropriate and complete conclusion
	○ Provides a clear but not perfectly organized explanation, using correct terminology, of what was done and why, but explanation may be slightly incomplete ○ May miss necessary assumptions or caveats ○ Uses diagrams or plots when appropriate to aid in describing the solution ○ States a conclusion that follows from the analysis but may be somewhat incomplete
	○ Provides some explanation of what was done, but explanation may be vague and difficult to interpret, and terminology may be somewhat inappropriate ○ Uses diagrams in an incomplete or ineffective way, or diagrams may be missing States a conclusion that is incomplete ○ Provides a minimal or unclear explanation of what was done or why it was done, and explanation may not match the presented solution ○ Fails to use diagrams or plots, or uses them incorrectly ○ States an incorrect conclusion or fails to state a conclusion Lowest ○ Provides no explanation of a legitimate strategy

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Since statistical knowledge and communication are both considered, students cannot achieve top scores if their communication skills are weak.

The following sample student responses help illustrate the importance of good communication.

Sample 1: Poor Communication

"Matrix used on calc. X2 = .51686, p= .99996 results in an insignificant p-value. No effective conclusion can be made that there is an association between the active ingredient in the two brands of pills and the pharmacy." (2001 exam, Question 5)

Comments: This student may know something, but you can't really tell it from this response!

Sample 2: Weak Communication

"It isn't an outlier because it is within the IQR." (2001 exam, Question 1c)

Comments: This response isn't worded correctly (within IQR doesn't make sense since the IQR is a single number), but you can sort of tell what the student means by this comment.

Sample 3: Adequate Communication

"10 inches of rainfall is not outstanding at all. The mean is 14.941 with a standard deviation of 6.747. That implies that 67% of the data is between 14.941 ± 6.747. A z score can be used to determine the exact probability." (Calculations followed.) (2001 exam, Question 1c)

Comments: This student used incorrect reasoning (the distribution was not normal), but it is clear what the student is doing, and the response shows some understanding.

Sample 4: Good Communication

"Since we want at least a pain relief of 50, drug B at 400 milligrams would be better than any of the strengths of drug A because the plot is of averages. For drug A, some patients might have had no pain relief and others 100 -- so it averaged 50. But drug B at 400 milligrams shows that most of the time the relief would be above 50 therefore bringing the average up to 90." (2000 exam, Question 1c)

Comment: This isn't the answer that was expected, but the idea is well communicated, and the student shows understanding of the distinction between averages and individual measurements. This student clearly understands the information provided by the graph and received a good score for this problem even though the scoring rubric was looking for an answer that justified the choice of drug A at a low dose.

Developing Good Communication Skills

What can AP Statistics teachers do to help students communicate effectively when writing about statistics? Here are some suggestions:

- Ask questions that require explanation and interpretation throughout the year. Communication and interpretation are just as important in early course topics as they are toward the end when you cover inferential methods.
- Don't accept "mechanics only" answers as correct on homework, quizzes, or exams.
- Don't accept "calculator talk" as an explanation of what is being done. "I entered x:20, n:400, and .95 on my TI-83. 1 prop z-int printout is .02864, .07136." (a sample student response on Question 6a of the 2000 exam) is NOT a good explanation of what is being done and why!
- Model good communication for your students. When doing examples in class, don't stop when you finish the mechanics. Make sure to always carry through to a conclusion or interpretation in context.
- Encourage your students to read as well as write. Reading the textbook helps students see how to communicate statistical ideas. Reading problems carefully is important too.
- Ask students to write about statistical concepts and processes. Many students had difficulty describing processes -- how to tell if there are outliers in a data set, how to carry out a simulation, and so forth.

Good statistical communication, like many other skills, is something that improves with practice. If students understand why it is important for the communication of results and have frequent opportunities to practice, they may surprise you with what they can do at the end of the year. It may be painful to read early attempts, but don't give up! Consistent expectations and good feedback can provide rewarding results.

References

Cobb, George W. and David S. Moore. "Mathematics, Statistics, and Teaching." *American Mathematics Monthly* (1997): 104, 801-823.
Watkins, Ann, Rosemary Roberts, Chris Olsen, and Richard Scheaffer. *Teacher's Guide for AP Statistics*. The College Board®, 1997.
