GAISE 2007: A Statistics Odyssey

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USCOTS 2007 Breakout Session

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Break-out Session

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Overview

- What are the GAISE recommendations and how can they be implemented?
  - Discussion of recommendations
  - Sample activities
  - Ways to implement the GAISE recommendations in YOUR classrooms
  - GAISE beyond the introductory course

Guideline #1: Emphasize statistical literacy and develop statistical thinking

- Assignments involve data collection, data exploration, and collaboration with peers
- Students use software (Fathom or Minitab) often throughout the semester
- Students are encouraged to explore and critique statistical applets, web resources, graphs, and articles that use statistics
- The instructor and teaching assistant attempt to model statistical thinking

Guideline #2: Use real data

- Students complete a survey at the beginning of the course and use the survey data for several activities
- Students gather and explore data often in class
- Students collect data for a project that involves comparing two groups

Guideline #3: Stress conceptual understanding rather than knowledge of procedures

- Cooperative learning is emphasized in the classroom
- Online students participate in small-group assignments that involve generating answers to conceptual questions
- Technology is emphasized as a way to perform calculations; few calculations are required on homework assignments or quizzes

Guideline #4: Foster Active Learning

- The course includes a combination of small-group assignments and individual activities
  - Small-group assignments involve:
    - Collaborating with peers to answer conceptual questions
  - Individual activities involve:
    - Entering and exploring data
    - Solving problems
    - Reasoning about concepts

Guideline #5: Use technology for developing concepts and analyzing data

- Fathom
- Tinkerplots
- Minitab
- Sampling SIM
- Statistical applets

Guideline #6: Integrate assessments that are aligned with course goals

- A variety of assessments are used throughout the course:
  - Homework/Lab Assignments
  - Group discussion assignments (in the online course)
  - Quizzes/Exams
    - Many items come from the ARTIST database
  - Projects
  - Weekly non-graded individual assignments/activities
  - Critiques of applets, graphs, articles, web sites

Sample Assessment Items

1. The following statement is statistically incorrect. Explain what is wrong. Student ratings of professors' teaching and colleagues' ratings of their research have a correlation of r = 1.21. This shows that those professors who are good teachers are also good researchers.

2. If two sets of data have exactly the same five-number summary then the two data sets must be identical. Do you agree or disagree? Explain your reasoning.

Another Sample Assessment Item

Alice, Ben, Connie and Dwayne have each taken a random sample of students from their school to estimate the variability in amount spent on movie tickets this summer. Alice asked 10 people, Ben 30, Connie 50, and Dwayne 70. Whose sample standard deviation probably differs most from the population parameter?

a. Alice

b. Ben

c. Connie

d. Dwayne

e. all differ about equally

Ways to Get Started

- Emphasize depth versus breadth
  - Are there particular topics you might cut from the course?
  - Are there new activities you can add to the course?
  - Can you implement more technology?
  - Can you save some class time by moving something less conceptual (e.g., instructions for using technology, repeated application) to homework or a lab?

Other issues to consider

- What are some of the impediments to implementing the GAISE recommendations?
  - Can we implement the GAISE recommendations beyond the introductory course?
  - Can we implement the recommendations in sequential courses, or courses that are prerequisites for other courses?
  - Can we "generalize" the recommendations to other populations of students or other departments?

Student Feedback

- "I thought it was going to be grueling and confusing with heaps of mathematical formulas. Everything has been manageable and I have been able to apply the concepts in this course to several other courses I am currently taking."
- "I think that the small group discussions and how we are to respond to questions and then to another student in the group really help in examining the content in a more detailed manner. The feedback from other students, with frequent comments and aid from the instructor, has been key in learning course material."

Student Feedback

- "I like this course. In high school, classes do fun projects like we do. Rather than just learning 'math' and skimming topics, however, we then take these activities more in depth to really understand statistics. The teaching style - learn by doing - is very helpful. I am learning way more than I possibly could in a math-based lecture format."
- "I like this class and I like how it's taught. I like the group work because it helps to hear it explained again from a peer. I like the activities and how they're related to what we learn."

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Guidelines for Assessment and Instruction in Statistics Education

Recommendations

1. Emphasize statistical literacy and develop statistical thinking.
2. Use real data.
3. Stress conceptual understanding rather than mere knowledge of procedures.
4. Foster active learning in the classroom.
5. Use technology for developing concepts and analyzing data.
6. Use assessments to improve and evaluate student learning.

Suggestions for teachers:

- Adding an activity to your course
- Having your students do a small project
- Integrating an applet into a lecture
- Demonstrating the use of software to your students
- Increasing the use of real data sets
- Deleting a topic from the list you currently try to cover to use the time saved to focus more on understanding concepts.

Introductory Activity: Questions on Backs

Authors: Allan Rossman and Mary Mortlock

Summary:
This activity provides a fun, casual introduction to statistics as the science of data and to the usefulness of graphical displaying for conveying numerical information. It also serves as an "ice-breaker" activity and an opportunity for people to mingle and get to know each other.

After completing this activity, students should:

- Have experienced a fun introductory activity that gives them a chance to interact with each other
- Begin to understand the fundamental idea that statistics is about *data* and that *context matters*
- Begin to understand the fundamental principle of variability: *data vary*
- Appreciate the usefulness of graphs for conveying information about data

Each participant has a question taped to his/her back. He/she records on an index card the numerical answers to the question as told to him/her by other participants. Then the participant creates a graph (and kind of graph, preferably a creative one) of the responses. The participant also tries to guess what the question was based on the responses and records this guess on his/her graph. When all graphs have been created, participants take turns describing their graphs and explaining their guesses, before they turn around and discover the question that was actually on their back.

At the beginning of this activity, participants should be cautioned to only give a number as their answer. Do not use units (dollars, miles, etc.) and try not to give any reaction that would "give the question away." Participants should be told that for many questions they may need to provide a guess of the answer and that "your" in a question refers to them and not to the person whose back contains the question.

The primary goals of this activity are:

- To provide a fun introductory activity and give students a chance to interact with each other
- To introduce the fundamental idea that statistics is about *data* and that *context matters*
- To introduce the fundamental principle: *data vary*
- To demonstrate the usefulness of graphs for conveying information about data

The questions should be chosen as likely to interest the participants involves. A mixture of questions likely to produce little variation and questions likely to generate lots of variation is desirable. It is also useful to use some questions with a single correct answer and others with opinions or tastes as answers.

Questions could include:

- How many years has it been since your school was founded?
- How many dwarfs does Snow White meet?
- How many pets do you have?
- For how many years have you been teaching?
- How many miles is your home from downtown Minneapolis?
- How many years has it been since John F. Kennedy was shot?
- How many points did Michael Jordan score on average per basketball game in his career?
- What do you consider the ideal temperature in degrees Fahrenheit?
- How many people live in your household?
- How many miles is the earth from the sun?
- What is the population of Ohio?
- What is the U.S. minimum wage in dollars?
- Pick a “random” number between 1 and 10.
- How many miles are on your car’s odometer?
- How many siblings do you have?
- What is the most money (in dollars) you ever paid for watching a movie?
- What is the most money (in dollars) you ever paid for a haircut?
- How many years old is President Bush?
- How many counties are in Minnesota?
- What is the last digit of your telephone number?
- What is the first digit of your telephone number (without the area code)?
- How many hours of sleep did you get last night?
- How many students did you teach last year?
- What is the salary (in dollars) of a brand-new teacher hired by your school?
- What is the median price (in dollars) of a house in Hennepin county?
- How many days are in the month that you were born in?
- What is the last digit of your zip code?
- How many pairs of shoes do you own?
- How many pairs of shoes did you bring with you this week?
- What is the median age of the people in this room?
- How many letters are there in the name of your home state?
- On a scale of 1 – 10 (1 = very nervous, 10 = not nervous at all), how nervous are you about this course?
- How many children do you have?
- How many different planes did you take to get here?
- How many Harry Potter books have you read?
- How many major league baseball teams are there in the U.S.?
- How many hours (not necessarily an integer) did it take you to travel here?

Lesson Plan: Reading and Interpreting Scatterplots/Correlation

Student Goals for the Lesson:

1. Understand the nature of bivariate data (i.e. What bivariate data is? What points in a scatterplot represent?)
2. Describe shape (form), trend (direction), and variation (strength) in a scatterplot and interpret those in the context of the data
3. Answer contextual questions using information obtained from a scatterplot
4. Know that a scatterplot is the appropriate graph to create to answer certain questions about the relationship between two quantitative variables
5. To estimate correlation from a scatterplot
6. To understand that correlation should not be computed from data that is not linear
7. To understand that a high correlation does not imply that the data are linear
8. To understand that there is a relationship between r and the slope of the regression line
9. To be aware of lurking variables and to understand that correlation does not imply causation
10.

Big Statistical Themes: Distribution (What does it look like?), Variability (What is the overall scatter? Is it same/different at different levels of x?), Inference (Are we willing to generalize about the relationship?)

Student Worksheet(s):

1. Credit Questions
2. Admissions Questions

Computer Files:

1. Fathom File of University of Minnesota Admissions Data

Other Materials/Resources Needed: None

Discussion: University guidance counselors are interested in the way in the number of credits students are accumulating as they progress throughout their academic careers. How long does it take a student to reach 60 credits (the requirement to reach Junior status)? How is the length of time a college student has been in school and the number of credits he/she has accumulated related? Imagine if we could track students throughout their academic careers. Would we expect the average number of credits that these students have accumulated to remain the same from semester to semester? How about the variation in the total number of credits accumulated?

Activity #1: Using time series data (cumulative credits conditioned on semester), students, in groups, will create boxplots based on their predictions of what those distributions will look like. The discussion will focus on comparisons of the number of credits (Shape, center, and spread) across time. Special attention will be put on comparing center and variation across the different distributions. Have students complete questions (a)-(g) on the *Credits Questions* worksheet.

Worksheet/Discussion Questions:
1. Are the shapes of the distributions consistent over time? Do we expect that given the data? Why or why not?
2. Is the center consistent over time? Do we expect that given the data? Why or why not?
3. Is the variability consistent over time? Do we expect that given the data? Why or why not?
4. How did the actual graph compare to your hypothesized graph?

Discussion: Talk to students about the actual data/plots. When are the boxplots symmetric? When are they skewed? What is the relationship between the length of time a college student has been in school and the number of credits he/she has accumulated? Here, get students to focus on examining the overall trend as well as the variation (Is it constant? Changing? How?)

Activity #2: Have students examine the scatterplot of gestation period and lifespan. Talk to them about the differences between a scatterplot and the conditional boxplots. Both can be used to examine how the distribution of y (lifespan in this case) changes for different values of x (gestation period). In this case, the x-variable (gestation) has many different levels instead of only the 6 discrete levels with the fish data. This makes reading it a little more difficult, but the fundamental problem is the same. We still are interested in examining how the distribution in y (especially the mean trend and variation) changes across values in x. Try to get students to "slice" the data into vertical slivers so that they start to see values on x (gestation) that are near each other as being in the same distribution. This way they can compare the different distributions across the x-variable.

Worksheet/Discussion Questions:
1. Draw in, or imagine vertical line separators for every 100 days of gestation. (You will have a vertical line at 100, 200, 300, etc.) You should have about 7 slivers of data, which you can now imagine as different distributions.
2. Describe how the distribution of lifespan (think of each sliver of separated data as a different distribution) changes as the value of gestation period changes.
3. Describe the scatterplot. Does there seem to be a relationship between the two variables? What is it? Be sure to discuss the shape (in general as well as outliers and clusters), trend, and variation.

Discussion: Why do we need admissions criteria? How can we determine if we let in a "good" student? What is a good predictor of first-year GPA?

Activity #3: Guessing Correlations
http://www.stat.uiuc.edu/courses/stat100//java/guess/GCApplet.html
Have students go through this several times until they are comfortable estimating the degree of linearity (correlation) in a dataset. A discussion about the importance of

examining a scatterplot could take place here. One possibility for further exploration would be to have students examine the correlation in data sets that have relationships that are not linear (e.g. quadratic, or cyclic). Emphasize that the correlation coefficient only describes a linear relationship and it is not enough to just look at the correlation coefficient. Discuss the idea that the correlation coefficient helps summarize the relationship between two quantitative variables much like the mean or standard deviation can be used to describe/summarize a single variable. Based on this exercise, what would we estimate the correlation to be for the gestation/longevity data?

Activity #4: Using the admissions data students need to examine several relationships to determine which is the strongest predictor of first-year GPA. Have them examine scatterplots and correlations to help them make this determination. (*Note to Instructor: This is actual data and it is very messy. None of the variables are good linear predictors. This can lead to an excellent discussion of some of the problems inherent in actual data.*)

Discussion: Which "predictor" variable seemed to have the best relationship with first-year GPA? If [*variable*] is the best predictor, why do admissions offices gather the other variables? How did you choose? What criteria did you use? How can we tell? Would you feel comfortable suggesting that there is a relationship between a student's GPA and any of the "predictors"? Why or why not?

Wrap-up: What do each of the points in the scatterplot represent? What kind of questions could be answered by examining a scatterplot? What is considered a "low" correlation? What is the range of correlation? How can we tell by examining a scatterplot if it will have a positive or negative association? What does a scatterplot that has a low correlation look like? This would also be a good opportunity to discuss causation and the idea of lurking variables with students. Does a high correlation indicate causation? What do we need to do to show one variable causes another? Show an example of what might not work (e.g. College major [categorical data] vs. Number of credits [quantitative data]) and ask if it would be appropriate. Pose some questions that could be answered by looking at data in a scatterplot. (e.g. What is the relationship between…)

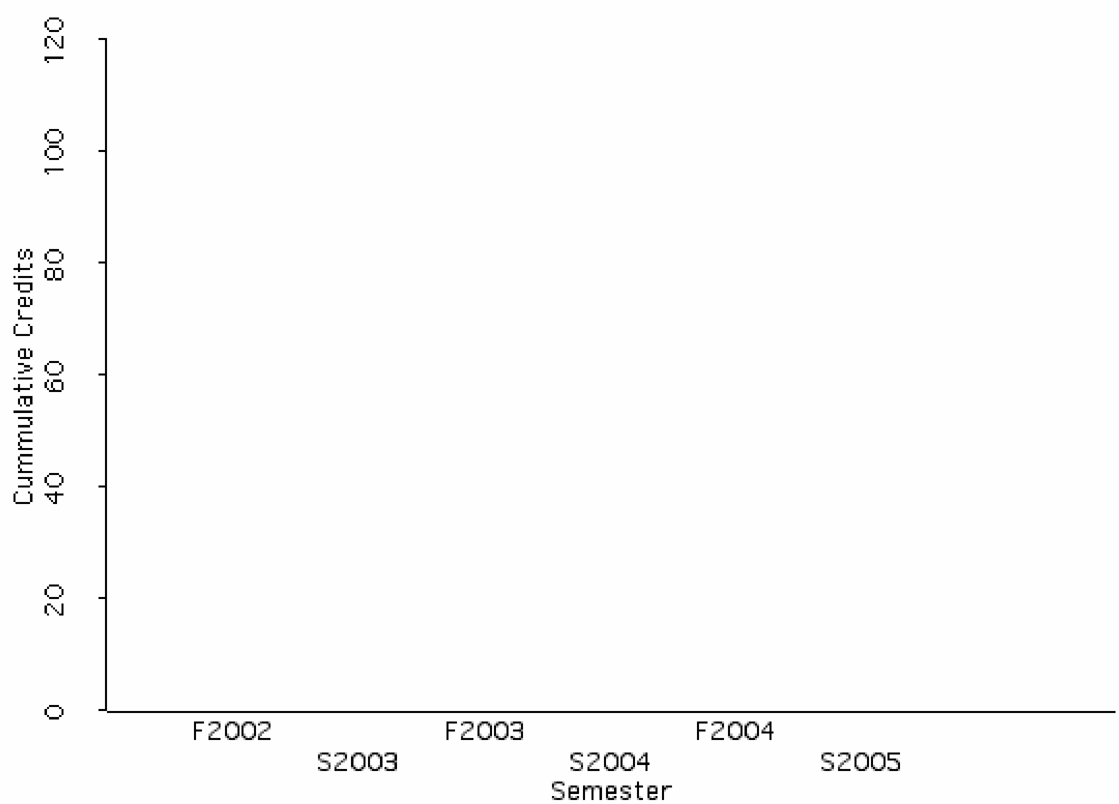
Assessment:

Credit Questions

Part I

How are the length of time a college student has been in school and the number of credits he/she has accumulated related? Imagine if you could track 100 students for 6 consecutive semesters. What would the distribution of these students' cumulative number of credits look like for each of those six semesters?

1. Draw box plots of what you believe the distribution of cumulative credits would look like for each of the six semesters. The students are all incoming freshmen (no transfer students) for the Fall 2002 semester and all 100 stay enrolled throughout the six semesters (no dropouts). [Hint: You should have six different boxplots…one for each semester from Fall 2002 (their first semester at the University) to Spring 2005 (after their third year at the university).] Don't forget to consider variation and shape in each of the box plots.

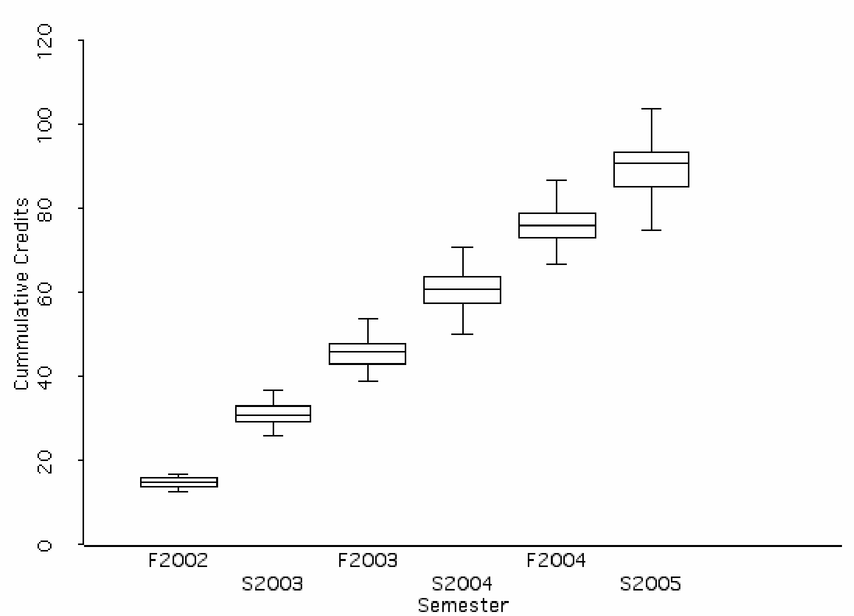


2. Are the shapes of the distributions consistent over time? Do we expect that given the data? Why or why not?

3. Is the center consistent over time? Do we expect that given the data? Why or why not?

4. Is the variability consistent over time? Do we expect that given the data? Why or why not?

5. Now, examine the actual box plots and summary statistics on the next page. These were actual data collected on a random sample of 100 students at the University of Minnesota who were enrolled in the College of Liberal Arts. How did they compare to your sketch? Were the shapes, centers, and variation consistent with what you expected to see? Explain why or why not.



Semester	Minimum	Q1	Median	Q3	Maximum
Fall 2002	11	13	15	16	19
Spr 2003	24	28	31	33	37
Fall 2003	35	43	46	48	57
Spr 2004	50	57.5	61	64	74
Fall 2004	60	73	76	79	90
Spr 2005	62	85.5	91	93.5	107

6. By examining the actual box plots, write down how you would explain to another person how the length of time a college student has been in school and the number of credits he/she has accumulated are related. Be sure to describe the variation as well as the overall trend.

7. Are you willing to generalize about the relationship you found to the population of all students at the University of Minnesota? Why or why not?

8. Does the change in semester *cause* the increase in cumulative credits?

9. Describe a variable that would be negatively related to semester. In other words, this variable would decrease as semester increased.

Lesson Plan: Measures of Spread—Standard Deviation

Sections 2.3 part 2 (Watkins, Scheaffer, Cobb)

Housekeeping:

Student Goals for the Lesson:

11. Understand different types of variability (when its desired and when its noise)
12. Understand standard deviation as a measure of spread

Big Statistical Themes: variability

Student Preparation: 2.3 pp 64-71, 75

Handouts:

1. Answers to SD activity

Data file:

1. Hand spans (from body measurements file)

Hook: Are you a deviant? How do you deviate from average?

Discussion: Variability in data is what we study in statistics. Variability is sometimes measured by the standard deviation, which is an average deviation from the center. What does that mean? How do outliers relate to variability of a data set? How do they affect the different measures? How can we determine if a data value is unusual? Someone has a height of 6 ft 7. Is that unusual? (Compared to what?)

What are two different kinds of variability we have looked at so far? (e.g., two types of head circumferences). How are they different? How are they similar? In each case, do we care if the variability is large or small?

Activity #1: *Hand spans: deviations from the mean* (p. 64)

Discussion: What are causes for the variability in Hand spans?

Activity #2: *Which standard deviation is larger or smaller?*

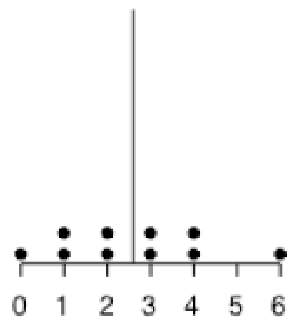
Wrap-up: What are some different sources of variability? Two kinds of variability: “diversity” (spice of life) and “standardization” (little variation). What are some different ways we can measure variability? What do the different measures tell us? Why do we need to measure variability in addition to center? How are center and spread related?

Assessment:

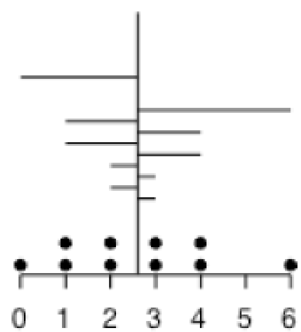
Which Standard Deviation is Larger or Smaller?

Part I

Before we begin the attached worksheet, we are going to think about the meaning of typical, or standard, deviation from the mean. First, examine the following dot plot which has the mean marked in the plot. Think about how large the deviations would be for each data point (dot).



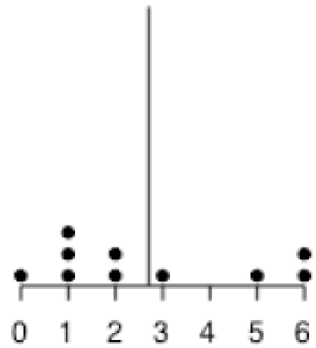
Next we will draw in each deviation from the mean.



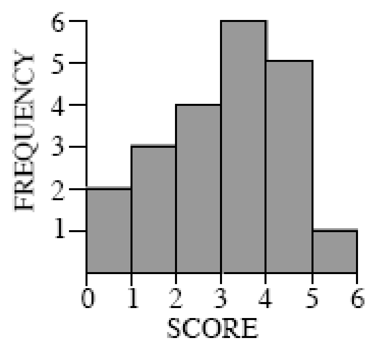
Now, think about the average size (length) of all of those deviations, and use this as an estimate for the size of the Standard Deviation. Don't worry about whether the deviation is to the left or right of the mean. Just consider all of the lengths. Draw the length of the standard deviation below.

Based on the scale in the graph, estimate a numerical value for the length of the line you drew above.

Repeat the process with this dot plot to help you draw and estimate the length of the standard deviation.



Now, try to draw and estimate the length of the standard deviation with the following histogram. The mean of the scores is 2.5. (Hint: Sketch in the appropriate number of dots in each bar of the histogram to make sure you have the appropriate number of deviations.)



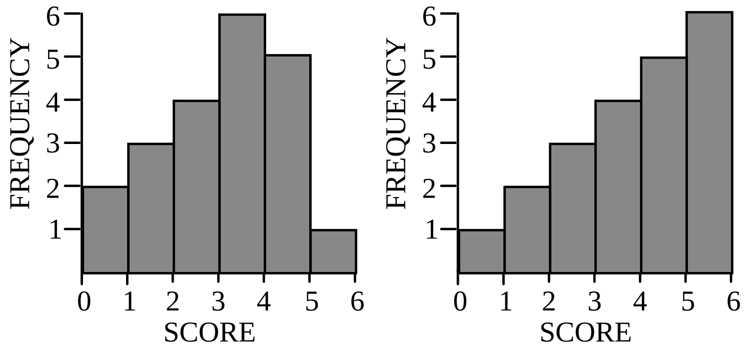
Part II: Comparing Standard Deviations

You will find 12 pairs of graphs on the next four pages. The mean for each graph (μ) is given just above each histogram. For each pair of graphs presented,

1. Indicate which one of the graphs has a larger standard deviation or if the two graphs have the same standard deviation.
2. Try to identify the characteristics of the graphs that make the standard deviation larger or smaller.

You can check your answers against the instructor's answer key as you complete each page.

1. **A** **μ = 2.57** **B** **μ = 3.33**

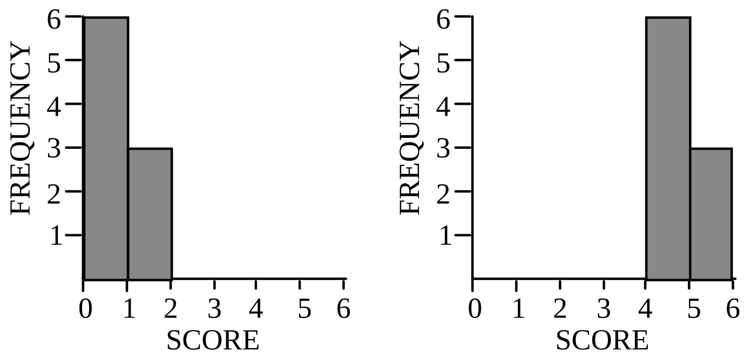


A has a larger standard deviation than B

B has a larger standard deviation than A

Both graphs have the same standard deviation

2. **A** **μ = .33** **B** **μ = 4.33**

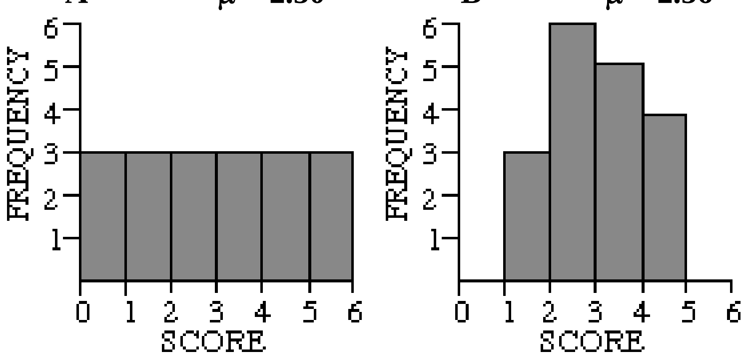


A has a larger standard deviation than B

B has a larger standard deviation than A

Both graphs have the same standard deviation

3. **A** **μ = 2.50** **B** **μ = 2.56**



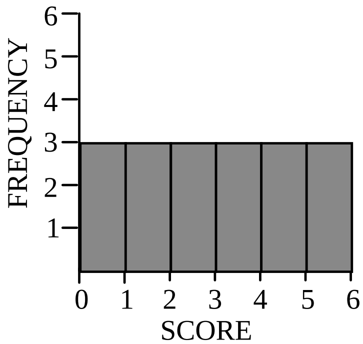
A has a larger standard deviation than B

B has a larger standard deviation than A

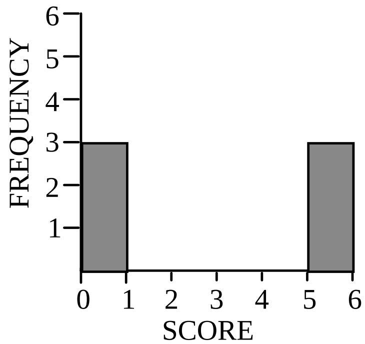
Both graphs have the same standard deviation

4.

A **μ = 2.50**



B **μ =2.50**



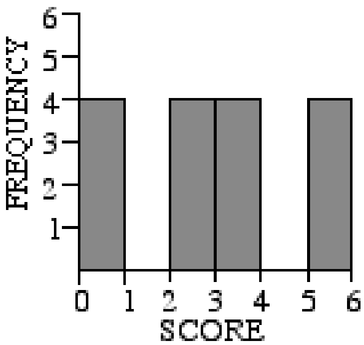
A has a larger standard deviation than B

B has a larger standard deviation than A

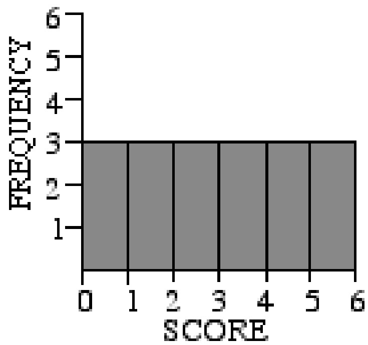
Both graphs have the same standard deviation

5.

A **μ = 2.50**



B **μ = 2.50**



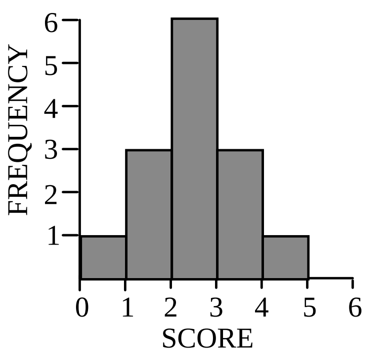
A has a larger standard deviation than B

B has a larger standard deviation than A

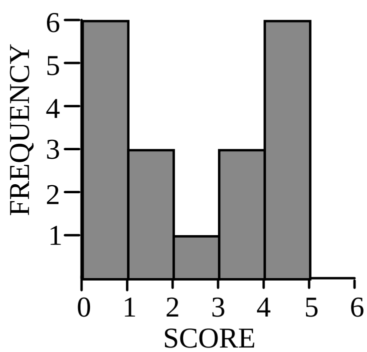
Both graphs have the same standard deviation

6.

A **μ = 2.00**



B **μ = 2.00**

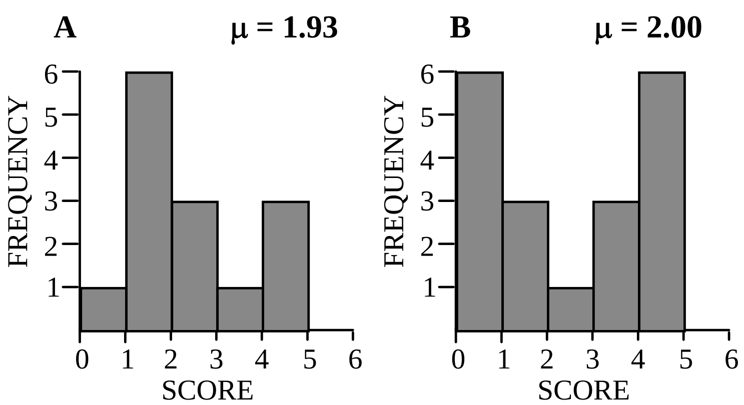


A has a larger standard deviation than B

B has a larger standard deviation than A

Both graphs have the same standard deviation

7.

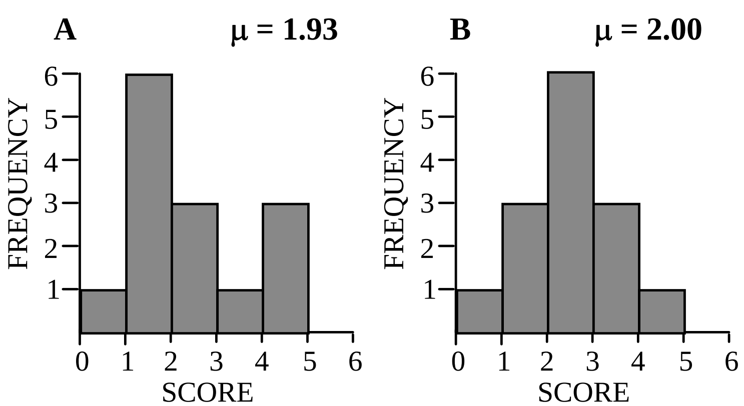


A has a larger standard deviation than B

B has a larger standard deviation than A

Both graphs have the same standard deviation

8.

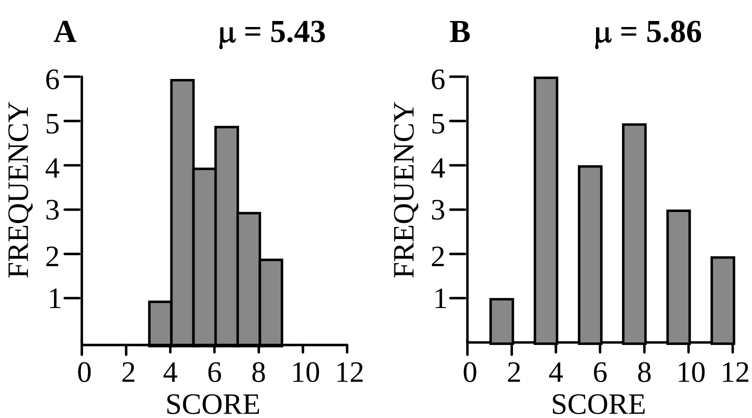


A has a larger standard deviation than B

B has a larger standard deviation than A

Both graphs have the same standard deviation

9.



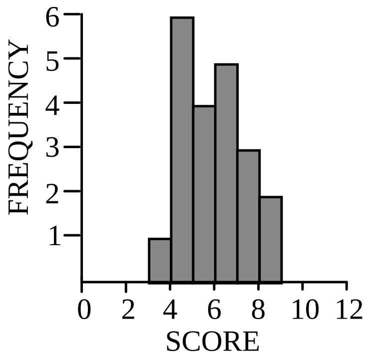
A has a larger standard deviation than B

B has a larger standard deviation than A

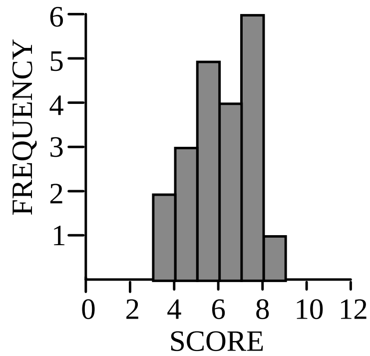
Both graphs have the same standard deviation

10.

A **μ = 5.43**



B **μ = 5.57**



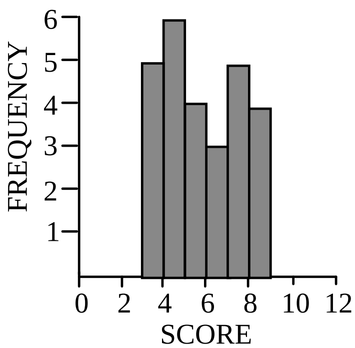
A has a larger standard deviation than B

B has a larger standard deviation than A

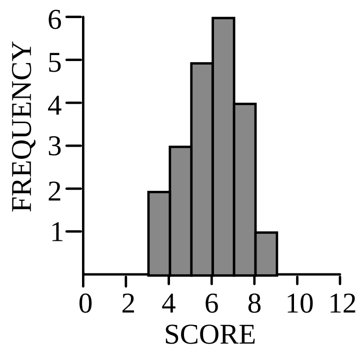
Both graphs have the same standard deviation

11.

A **μ = 5.33**



B **μ = 5.48**



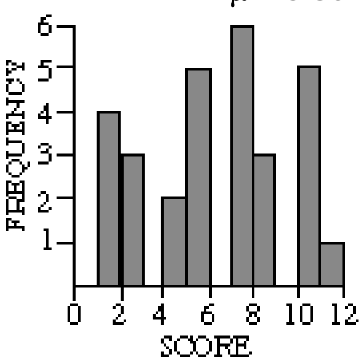
A has a larger standard deviation than B

B has a larger standard deviation than A

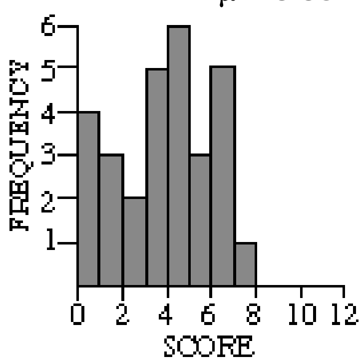
Both graphs have the same standard deviation

12.

A **μ = 5.86**



B **μ = 3.38**



A has a larger standard deviation than B

B has a larger standard deviation than A

Both graphs have the same standard deviation

ITEM	**sd of Graph A**	**sd of Graph B**	**Correct Decision**
1	$\sigma = 1.365$	$\sigma = 1.491$	**B** is larger
2	$\sigma = .471$	$\sigma = .471$	**SAME**
3	$\sigma = 1.708$	$\sigma = 1.012$	**A** is larger
4	$\sigma = 1.708$	$\sigma = 2.50$	**B** is larger
5	$\sigma = 1.803$	$\sigma = 1.708$	**A** is larger
6	$\sigma = 1.280$	$\sigma = 1.686$	**B** is larger
7	$\sigma = 1.743$	$\sigma = 1.743$	**SAME**
8	$\sigma = 1.743$	$\sigma = 1.332$	**A** is larger
9	$\sigma = 3.126$	$\sigma = 2.075$	**A** is larger

Resources

1. Guidelines for Assessment and Instruction in Statistics Education
   http://www.amstat.org/Education/gaise/

2. Consortium for the Advancement of Undergraduate Statistics Resources Page
   http://www.causeweb.org/resources/

3. SERC's Pedagogic Service Project
   http://serc.carleton.edu/sp/index.html

4. University of Minnesota – Educational Psychology – Undergraduate Statistics Page
   http://www.tc.umn.edu/~zief0002/3264.htm

5. Isolated Statisticians Discussion List
   http://www.lawrence.edu/fac/jordanj/isostat.html

6. Special Interest Group on Statistics Education - Mathematical Association of America
   http://www.pasles.org/sigmaastat/

7. Center for Statistics Education – American Statistical Association
   http://www.amstat.org/education/

8. Section on Statistical Education – American Statistical Association
   http://www.amstat.org/sections/educ/

9. Assessment Resource Tools for Improving Statistical Thinking (ARTIST)
   https://app.gen.umn.edu/artist/

10. Sampling SIM
    http://www.tc.umn.edu/~delma001/stat_tools/stat_tools_software.htm