Using Statistical Analysis

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Module Introduction

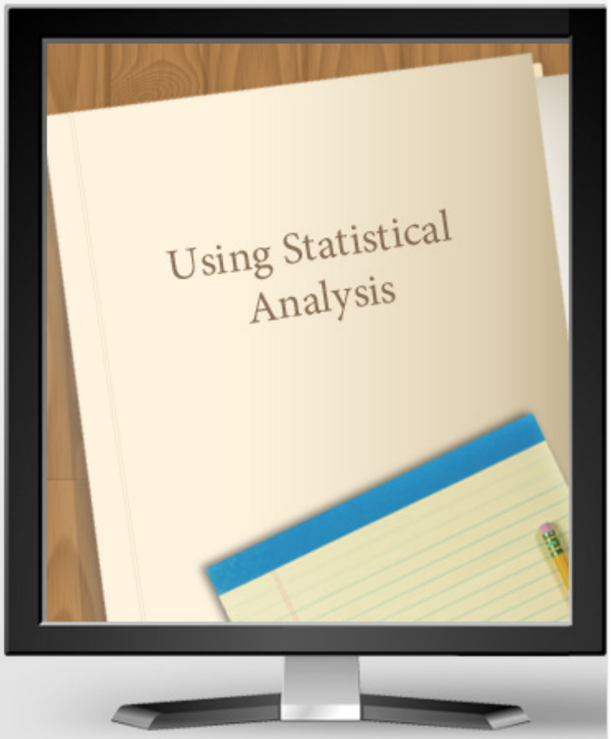
Welcome to Using Statistical Analysis!

You might be wondering, "How will the information in this module help me in my job as a contract specialist?"

As a contract specialist, you will need to use descriptive statistics to organize, summarize, analyze, and interpret data for contract pricing.

Did you know that the inflation rate for various commodity groups is a statistic which is very important in contract pricing?

This module will discuss the difference between descriptive and inferential statistics, provide you with a basic understanding of common statistical terms, and will identify contract situations where using statistics is appropriate.



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Using Statistical Analysis

Objectives

At the end of this module, you will be able to:

- Identify contract situations where statistical analysis is an appropriate tool for developing a prenegotiation objective
- Differentiate between the measures of central tendency and the methods for measuring dispersion
- Identify the process for establishing a confidence interval
- Identify the process for using stratified sampling
- Calculate a prenegotiation objective using the appropriate statistical analysis techniques

Sound good? All right, let's get started!

Select Next for a high-level overview of the content that will be presented in this module.

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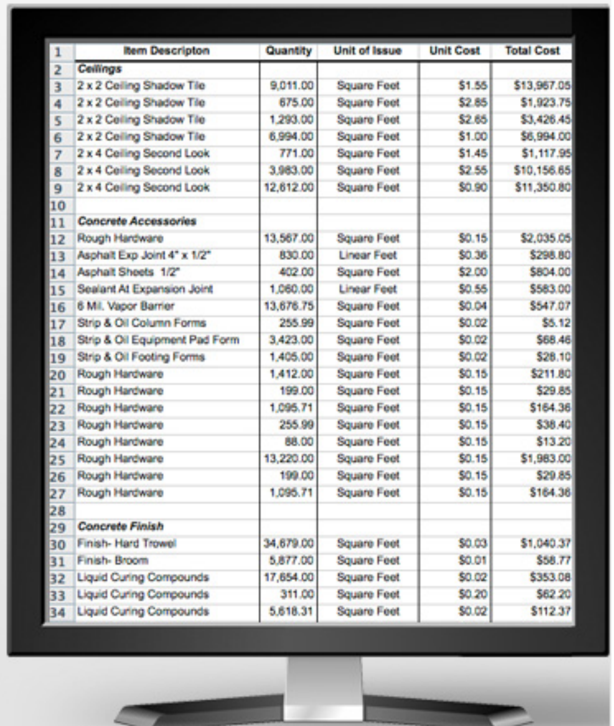
Overview - When is Statistical Analysis Appropriate?

There are certain contract situations where statistical analysis is very useful. It can be invaluable to you when:

- Developing government objectives for contract prices based on historical values
- Developing minimum and maximum price positions for negotiations
- Developing an estimate of risk for consideration in contract type selection
- Developing an estimate of risk for consideration in profit or fee analysis
- Streamlining the evaluation of a large quantity of data without sacrificing quality



1	Item Descripton	Quantity	Unit of Issue	Unit Cost	Total Cost
2	*Ceilings*				
3	2 x 2 Ceiling Shadow Tile	9,011.00	Square Feet	$1.55	$13,967.05
4	2 x 2 Ceiling Shadow Tile	675.00	Square Feet	$2.85	$1,923.75
5	2 x 2 Ceiling Shadow Tile	1,293.00	Square Feet	$2.65	$3,426.45
6	2 x 2 Ceiling Shadow Tile	6,994.00	Square Feet	$1.00	$6,994.00
7	2 x 4 Ceiling Second Look	771.00	Square Feet	$1.45	$1,117.95
8	2 x 4 Ceiling Second Look	3,983.00	Square Feet	$2.55	$10,156.65
9	2 x 4 Ceiling Second Look	12,612.00	Square Feet	$0.90	$11,350.80
10					
11	*Concrete Accessories*				
12	Rough Hardware	13,567.00	Square Feet	$0.15	$2,035.05
13	Asphalt Exp Joint 4" x 1/2"	830.00	Linear Feet	$0.36	$298.80
14	Asphalt Sheets 1/2"	402.00	Square Feet	$2.00	$804.00
15	Sealant At Expansion Joint	1,060.00	Linear Feet	$0.55	$583.00
16	6 Mil. Vapor Barrier	13,676.75	Square Feet	$0.04	$547.07
17	Strip & Oil Column Forms	255.99	Square Feet	$0.02	$5.12
18	Strip & Oil Equipment Pad Form	3,423.00	Square Feet	$0.02	$68.46
19	Strip & Oil Footing Forms	1,405.00	Square Feet	$0.02	$28.10
20	Rough Hardware	1,412.00	Square Feet	$0.15	$211.80
21	Rough Hardware	199.00	Square Feet	$0.15	$29.85
22	Rough Hardware	1,095.71	Square Feet	$0.15	$164.36
23	Rough Hardware	255.99	Square Feet	$0.15	$38.40
24	Rough Hardware	88.00	Square Feet	$0.15	$13.20
25	Rough Hardware	13,220.00	Square Feet	$0.15	$1,983.00
26	Rough Hardware	199.00	Square Feet	$0.15	$29.85
27	Rough Hardware	1,095.71	Square Feet	$0.15	$164.36
28					
29	*Concrete Finish*				
30	Finish- Hard Trowel	34,679.00	Square Feet	$0.03	$1,040.37
31	Finish- Broom	5,877.00	Square Feet	$0.01	$58.77
32	Liquid Curing Compounds	17,654.00	Square Feet	$0.02	$353.08
33	Liquid Curing Compounds	311.00	Square Feet	$0.20	$62.20
34	Liquid Curing Compounds	5,618.31	Square Feet	$0.02	$112.37

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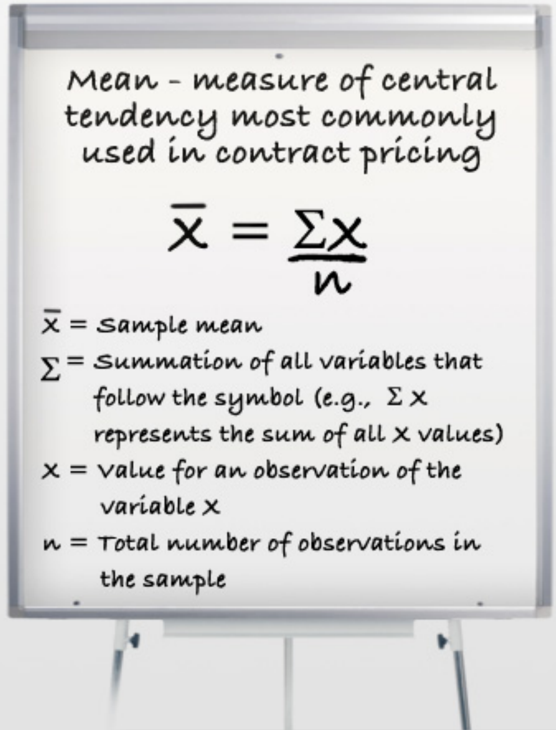
Overview - Measuring Central Tendency

A measure of central tendency is the central value around which data observations tend to cluster. It is the central value of distribution.

The three most common and useful measures of central tendency are:

- **Arithmetic mean** - add all observations in a data set and divide by the total number of observations
- **Median** - the middle value of a data set when the observations are arranged from lowest to highest (or vice versa)
- **Mode** - the value with the highest frequency in the data set



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Overview - Measuring Dispersion

Although the mean for a data set is a value around which the other values tend to cluster, it conveys no indication of the closeness, or dispersion, of the clustering.

There are several measures of **absolute dispersion** commonly used to describe the variation within a data set. This includes the **range**, **mean absolute deviation**, **variance**, and **standard deviation**.

Contractor Scrap Rate Data		
Month	**Dept. A, Fabrication**	**Dept. B, Assembly**
February	.065	.050
March	.035	.048
April	.042	.052
May	.058	.053
June	.032	.048
July	.068	.049
Total	.300	.300
Mean	.050	.050

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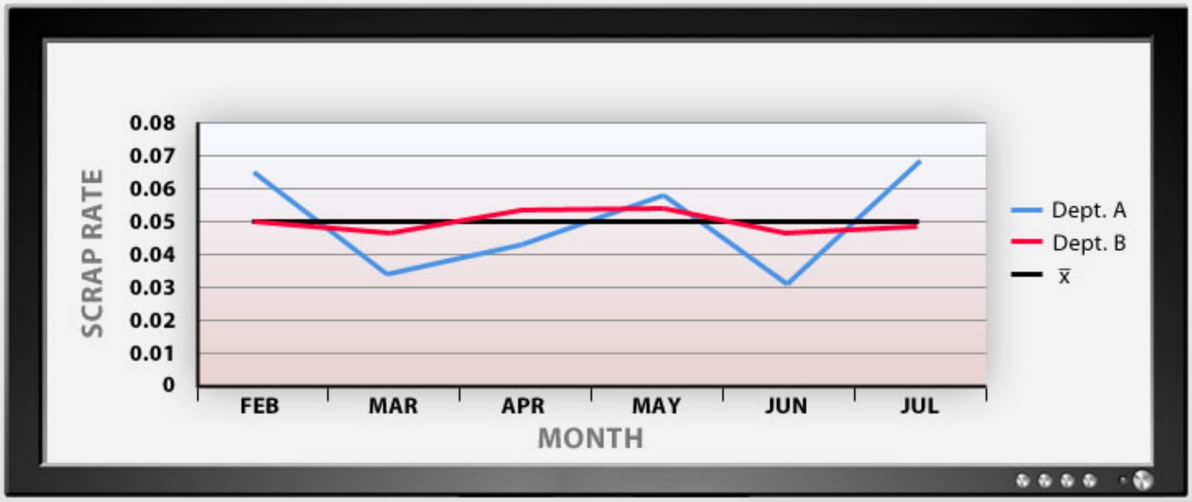
Overview - Absolute Dispersion (cont.)

The mean scrap rate for both departments is the same - 5 %. However, the monthly scrap rates in Department B show less dispersion around the mean; hence, you would feel more comfortable forecasting a scrap rate of 5% for Department B.



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Overview - Relative Dispersion

One measure of relative dispersion, the coefficient of variation, is useful when the means of a data set are not equal. Here, you have Department A and Department C. The mean scrap rate for Department C is 5% and the mean scrap rate for Department C is 6.25%.

Month	Dept. A	Dept. C
February	.065	.07
March	.035	.06
April	.042	.06
May	.058	.075
June	.032	.045
July	.068	.065

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Overview - Relative Dispersion (cont.)

Which data set contains more dispersion? The Coefficient of Variation will help you decide.

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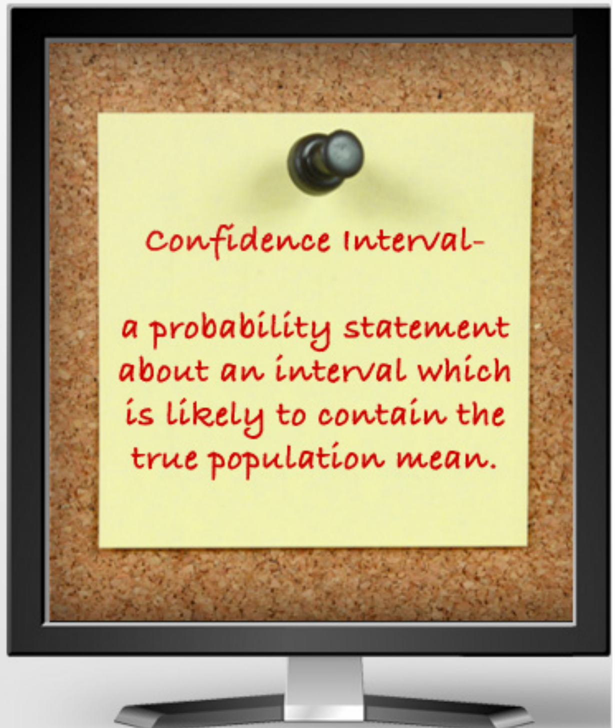
Overview - Establishing a Confidence Interval

You can combine the sample mean and sample standard deviation with an understanding of the shape of the distribution of sample means to develop a **confidence interval**.



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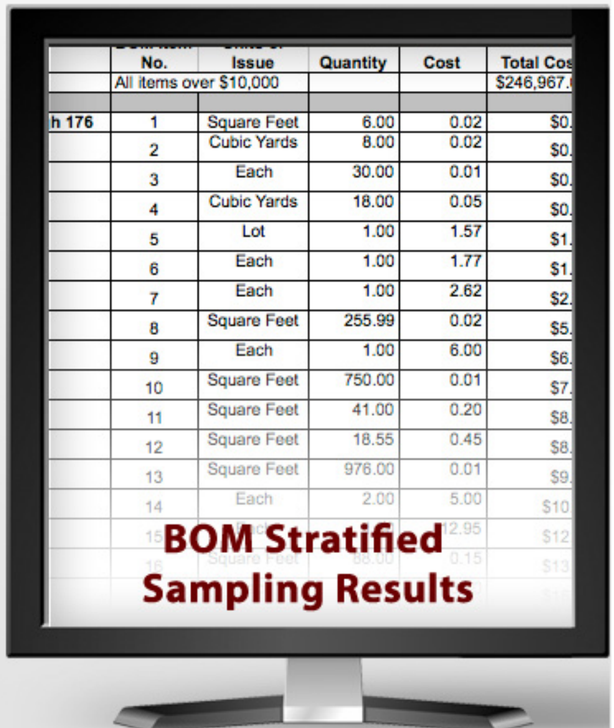
Overview - Stratified Sampling in Contract Pricing

You should consider using sampling when you have a large amount of data and limited time to conduct your analysis.

Stratified sampling is the most efficient and effective method of sampling for cost/price analysis.

Stratified sampling allows you to concentrate your efforts on the items with the greatest potential for cost/price reduction while using random sampling procedures to identify any general pattern of overpricing of smaller value items.



	No.	Issue	Quantity	Cost	Total Cos
	All items over $10,000				$246,967.
h 176	1	Square Feet	6.00	0.02	$0.
	2	Cubic Yards	8.00	0.02	$0.
	3	Each	30.00	0.01	$0.
	4	Cubic Yards	18.00	0.05	$0.
	5	Lot	1.00	1.57	$1.
	6	Each	1.00	1.77	$1.
	7	Each	1.00	2.62	$2.
	8	Square Feet	255.99	0.02	$5.
	9	Each	1.00	6.00	$6.
	10	Square Feet	750.00	0.01	$7.
	11	Square Feet	41.00	0.20	$8.
	12	Square Feet	18.55	0.45	$8.
	13	Square Feet	976.00	0.01	$9.
	14	Each	2.00	5.00	$10

D

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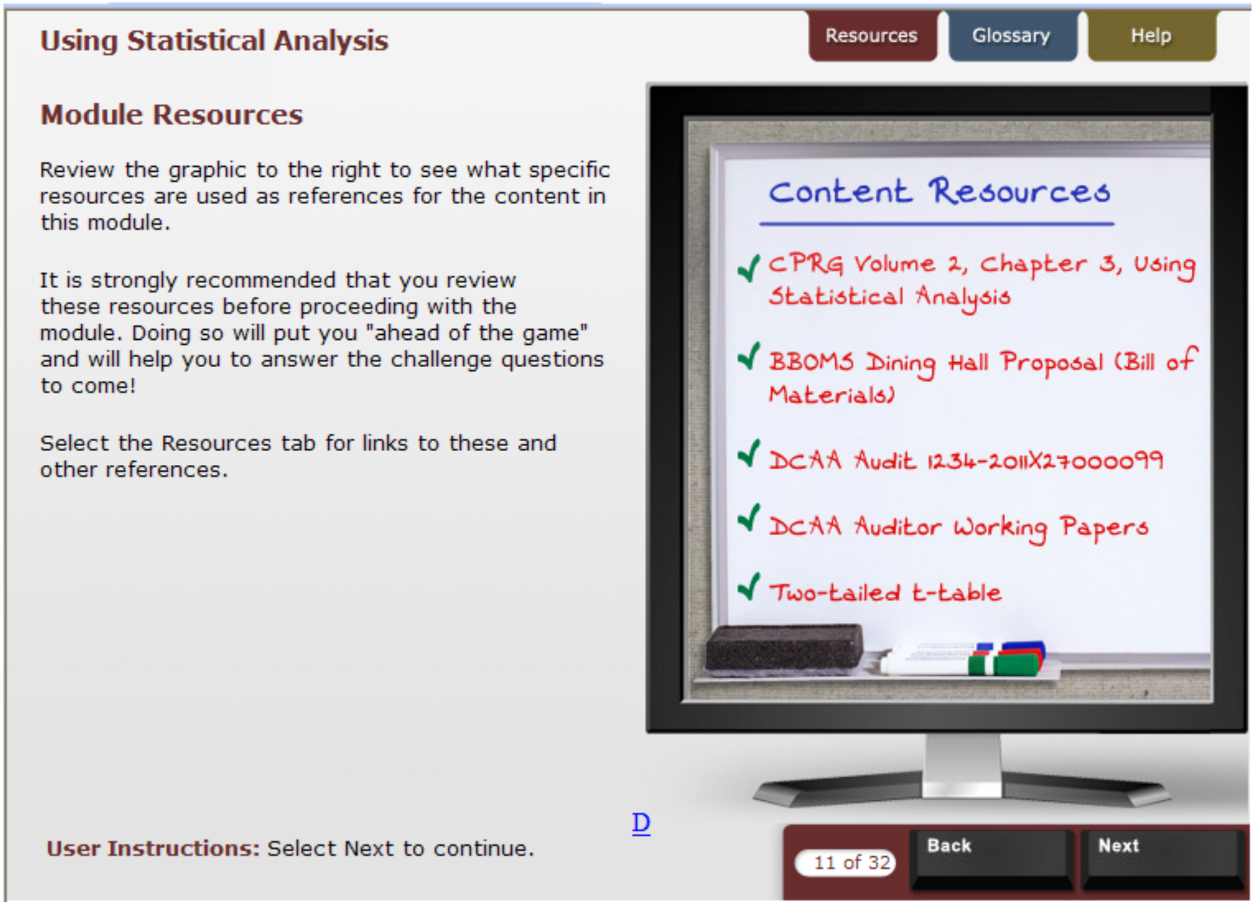
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Module Resources
Review the graphic to the right to see what specific resources are used as references for the content in this module.
It is strongly recommended that you review these resources before proceeding with the module. Doing so will put you "ahead of the game" and will help you to answer the challenge questions to come!
Select the Resources tab for links to these and other references.
Content Resources
CPRG Volume 2, Chapter 3, Using Statistical Analysis
BBOMS Dining Hall Proposal (Bill of Materials)
DCAA Audit 1234-2011X27000099
DCAA Auditor Working Papers
Two-tailed t-table
D
User Instructions: Select Next to continue.
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Using Statistical Analysis

Simulation Overview

In this module, you are going to answer a series of Challenge Questions about using statistical analysis. Do not worry if you miss a question - you will be directed to pertinent content and then given a chance to answer the question again.

Even if you get a question right the first time, it is **strongly** recommended that you elect to review the pertinent content by selecting the Review button. This review will help you answer the practice test questions at the end of the module.

Remember to use the Resources and Glossary tabs at any time during the simulation to access helpful information.

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User Instructions: Select Next to continue.

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REWIND
PLAY
CAPTIONS
Hi, it's Jessica, your Contracting Officer. When using quantitative techniques, it is important to identify situations in which statistical analysis would be useful.
User Instructions: Select Next to continue.
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REWIND
PLAY
CC
CAPTIONS
Review the contractor's BBOMS Dining Hall Proposal, particularly the Material Basis of Estimate, or BoE; the DCAA Audit Report, and the Auditor's Working Papers.
User Instructions: Select Next to continue.
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REWIND
PLAY
CC
CAPTIONS
Be sure to review each tab! Call me if you have any questions.
User Instructions: Select Next to continue.
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Using Statistical Analysis

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Challenge Question #1

Read the following situations in which statistical analysis might be used. Which one of the situations is similar to analyzing the contractor's Bill of Materials?

- A. Developing government objectives for contract prices based on historical values
- B. Developing minimum and maximum price positions for negotiations
- C. Developing an estimate of risk for consideration in contract type selection
- D. Streamlining the evaluation of a large quantity of data

Check Answer

User Instructions: Select the correct answer.

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When Statistical Analysis is Appropriate

Statistical analysis can be very helpful in the following contract situations:

Developing objectives for contract prices based on historical values - use statistical analysis to evaluate the historical data in making estimates for the future.

Developing minimum and maximum price positions for negotiations - use statistical analysis to assess the cost risk involved and use that assessment in developing your negotiation positions.

Developing an estimate of risk for consideration in contract type selection - if a pricing risk is so large on a firm fixed-price contract, consider a cost-reimbursement or incentive contract instead.

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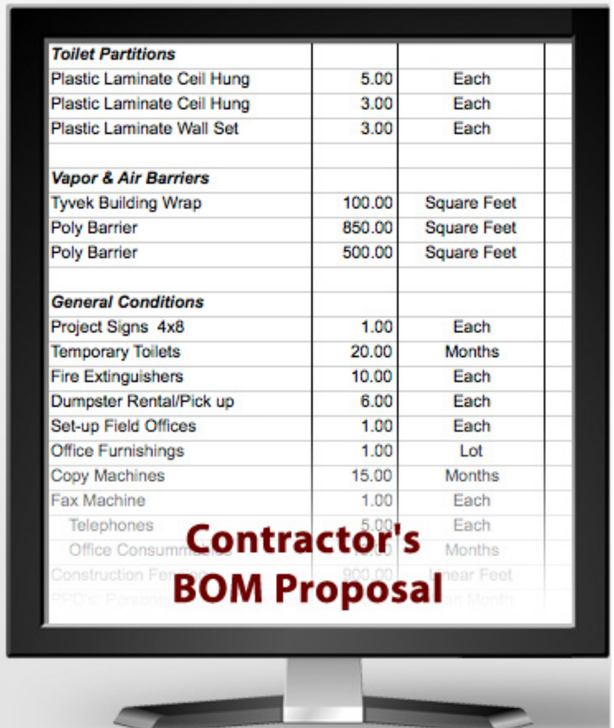
When Statistical Analysis is Appropriate (cont.)

Statistical analysis is also helpful in these contract situations:

Developing an estimate of risk for consideration in profit or fee analysis - the greater the dispersion of historical cost data, the greater the risk in prospective contract pricing.

Streamlining the evaluation of a large quantity of data - use stratified sampling to examine 100% of items with the greatest potential for cost reduction; random sampling assures there is no general pattern of overpricing small value items (if the sample is overpriced, good chances are that the entire stratum is, too.)



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Categories of Statistics

Now that you know the ideal situations in which statistics would benefit you in your job as a contract specialist, let's review the two broad categories of statistics.

The first category is **descriptive statistics**.

This includes a large variety of methods for summarizing or describing a set of numbers.

Measures of central tendency and measures of dispersion fall into this category because they describe the nature of the data collected.

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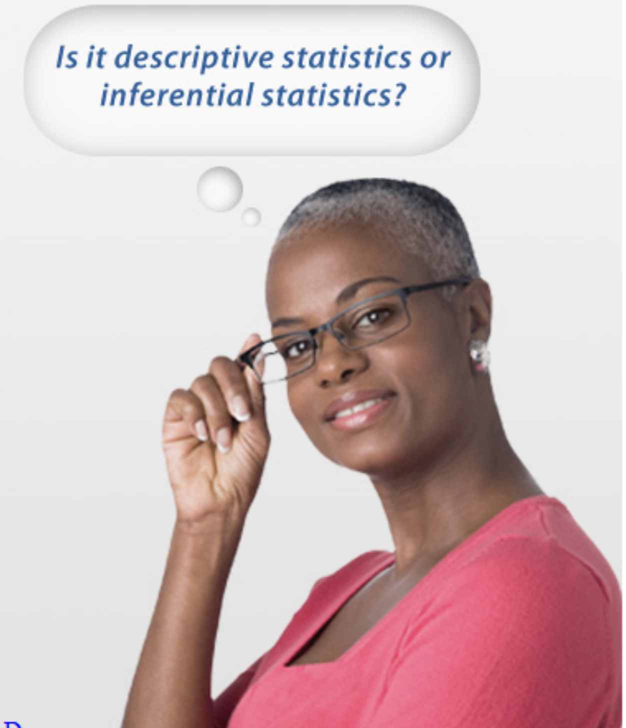
Categories of Statistics (cont.)

The other category is **inferential statistics**.

This category includes methods of using a sample data taken from a statistical population to make decisions, predictions, and generalizations related to a problem of interest.

Stratified sampling falls into this category and is often used in contract pricing.



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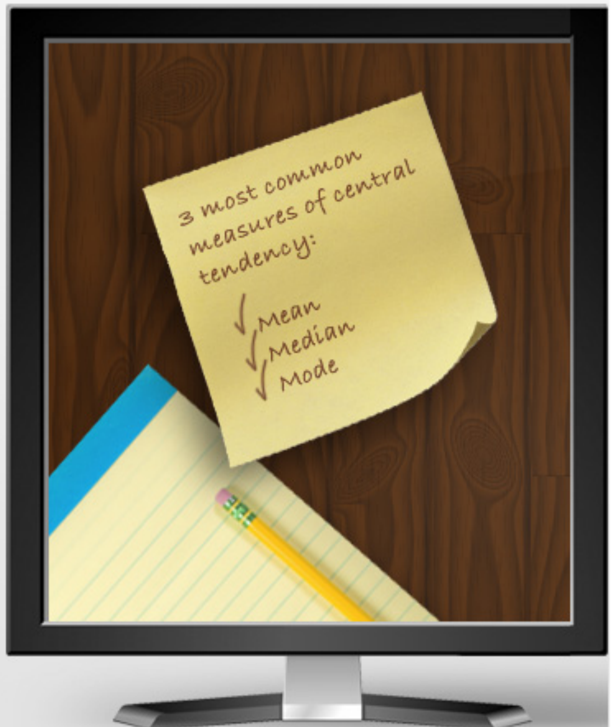
Measures of Central Tendency

You have been asked to prepare a solicitation for a product that your office has acquired several times before. Before you start, you should find out what your office has paid for this product in the past.

Instead of relying exclusively on the last price paid, you should collect data from the last several acquisitions.

To get a clearer picture of this array of data, you would likely want to calculate some measure of central tendency.

A measure of central tendency is the central value around which data observations (i.e., historical prices) tend to cluster. It is the central value of the distribution.



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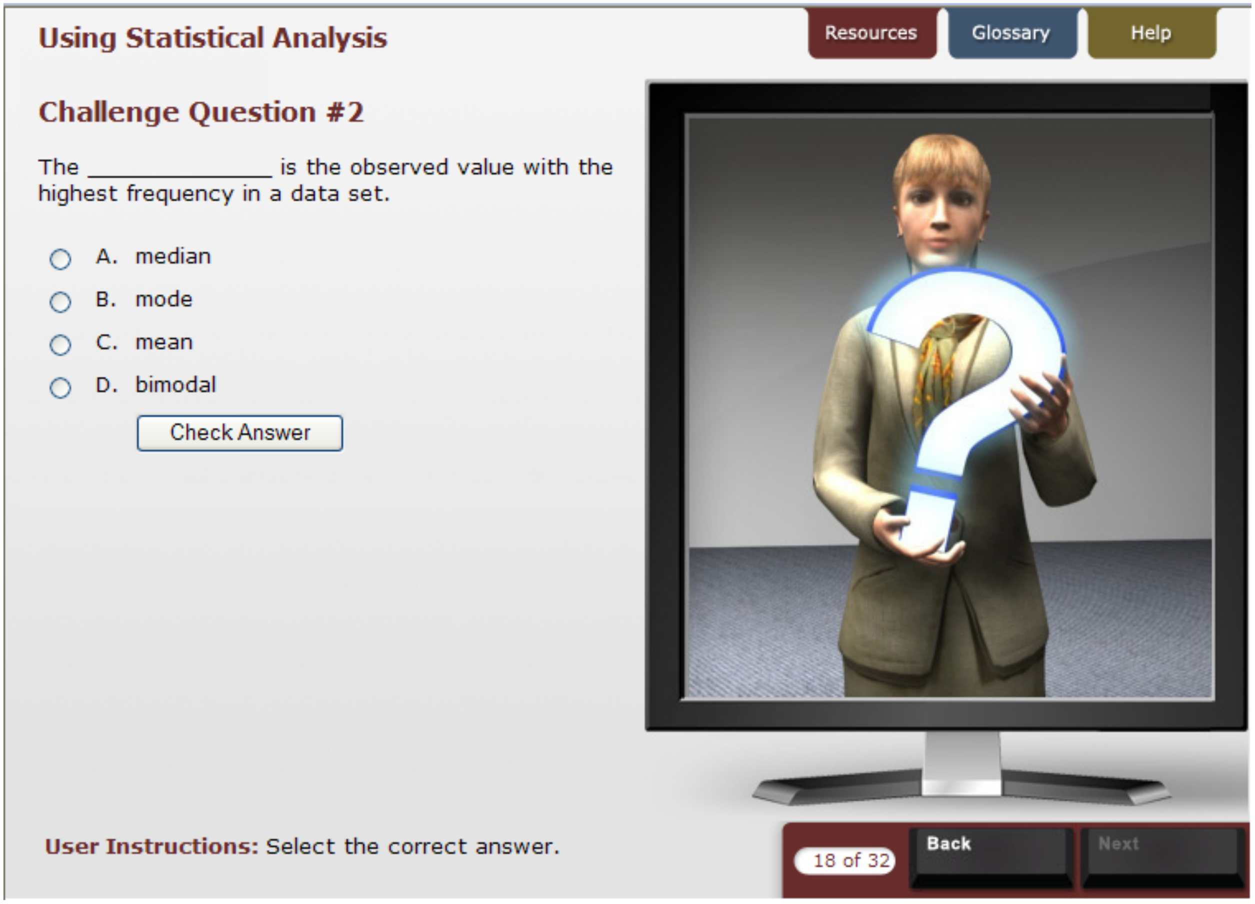
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Challenge Question #2
The ______________ is the observed value with the highest frequency in a data set.
A. median
B. mode
C. mean
D. bimodal
Check Answer
User Instructions: Select the correct answer.
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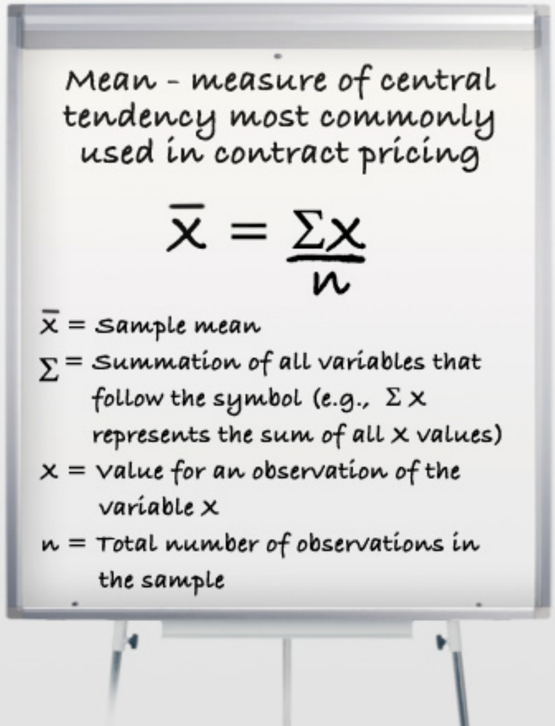
Using Statistical Analysis

Calculating the Arithmetic Mean

The arithmetic mean, or average, is the measure of central tendency most commonly used in contract pricing.

To calculate the mean, sum all observations in a set of data and divide by the number of observations.



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User Instructions: Select Next to continue.

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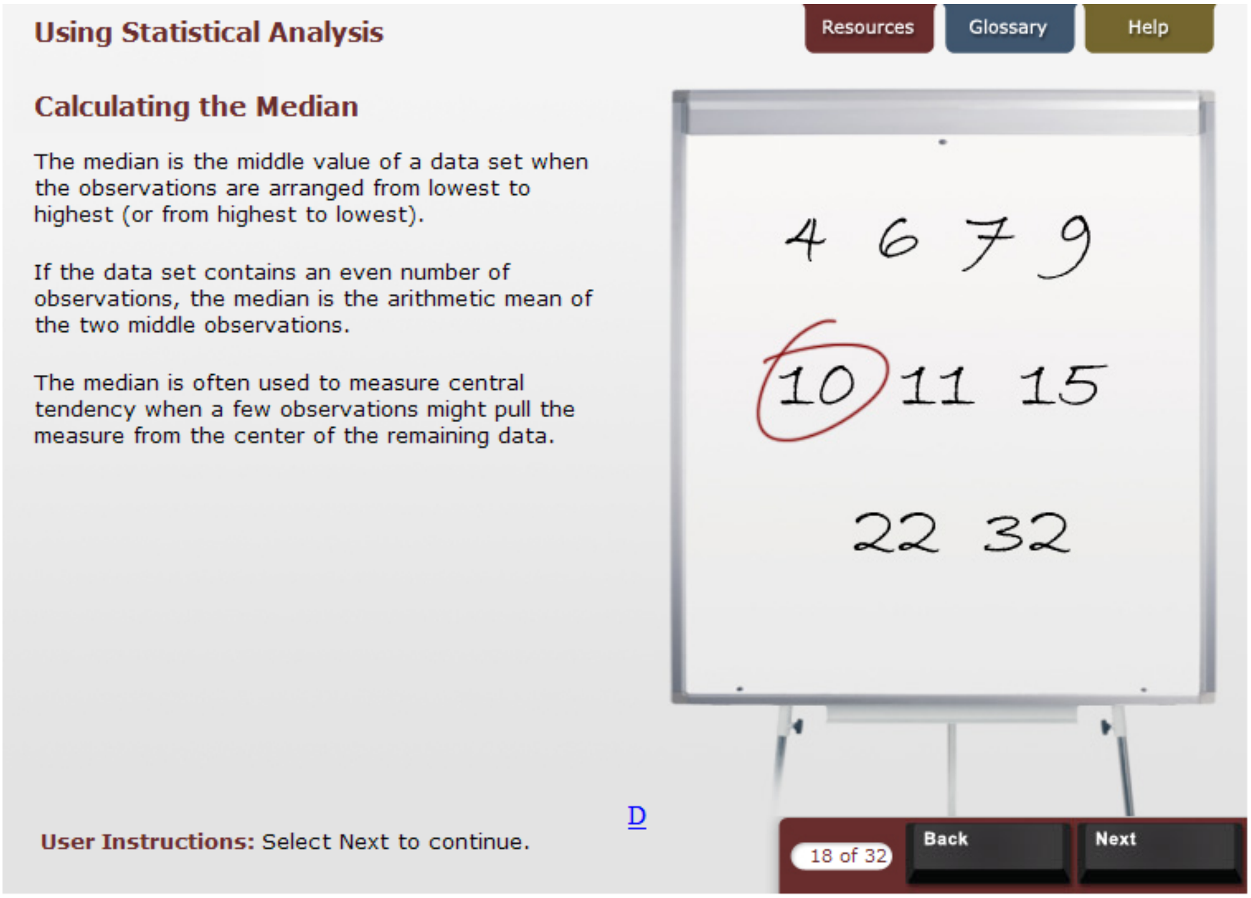
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Calculating the Median
The median is the middle value of a data set when the observations are arranged from lowest to highest (or from highest to lowest).
If the data set contains an even number of observations, the median is the arithmetic mean of the two middle observations.
The median is often used to measure central tendency when a few observations might pull the measure from the center of the remaining data.
4 6 7 9
10 11 15
22 32
D
User Instructions: Select Next to continue.
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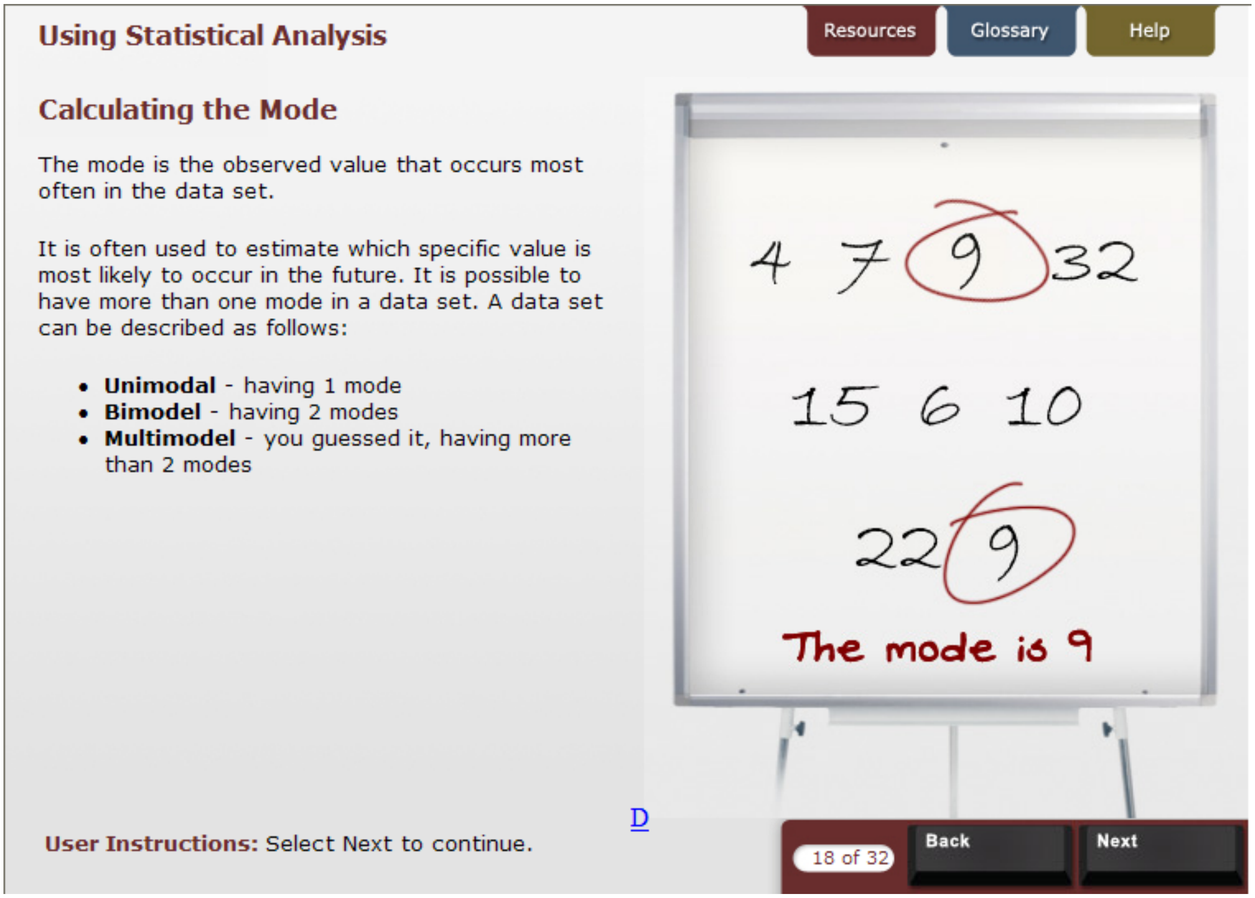
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Calculating the Mode
The mode is the observed value that occurs most often in the data set.
It is often used to estimate which specific value is most likely to occur in the future. It is possible to have more than one mode in a data set. A data set can be described as follows:
• Unimodal - having 1 mode
• Bimodel - having 2 modes
• Multimodel - you guessed it, having more than 2 modes
4 7 9 32
15 6 10
22 9
The mode is 9
D
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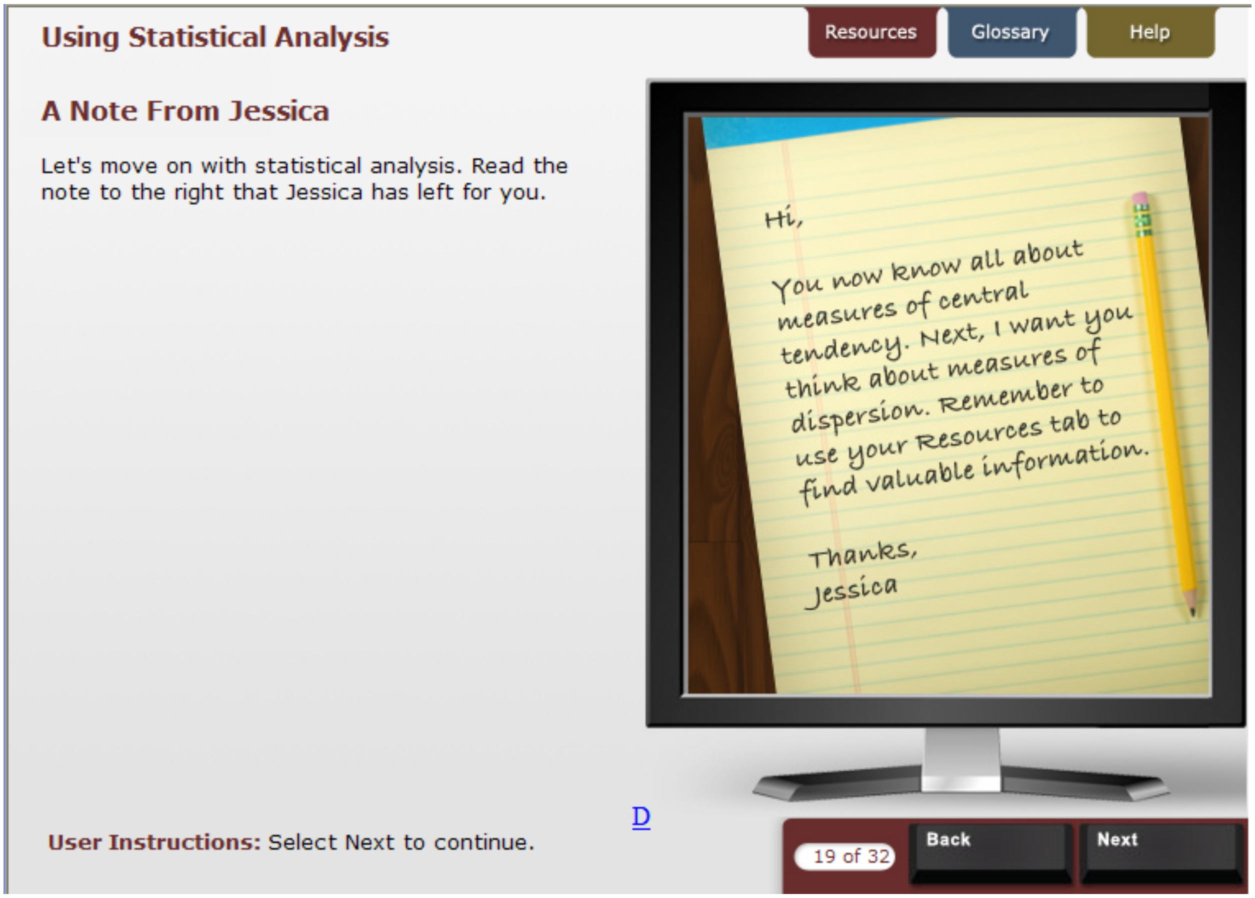
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A Note From Jessica
Let's move on with statistical analysis. Read the note to the right that Jessica has left for you.
Hi,
You now know all about measures of central tendency. Next, I want you think about measures of dispersion. Remember to use your Resources tab to find valuable information.
Thanks,
Jessica
D
User Instructions: Select Next to continue.
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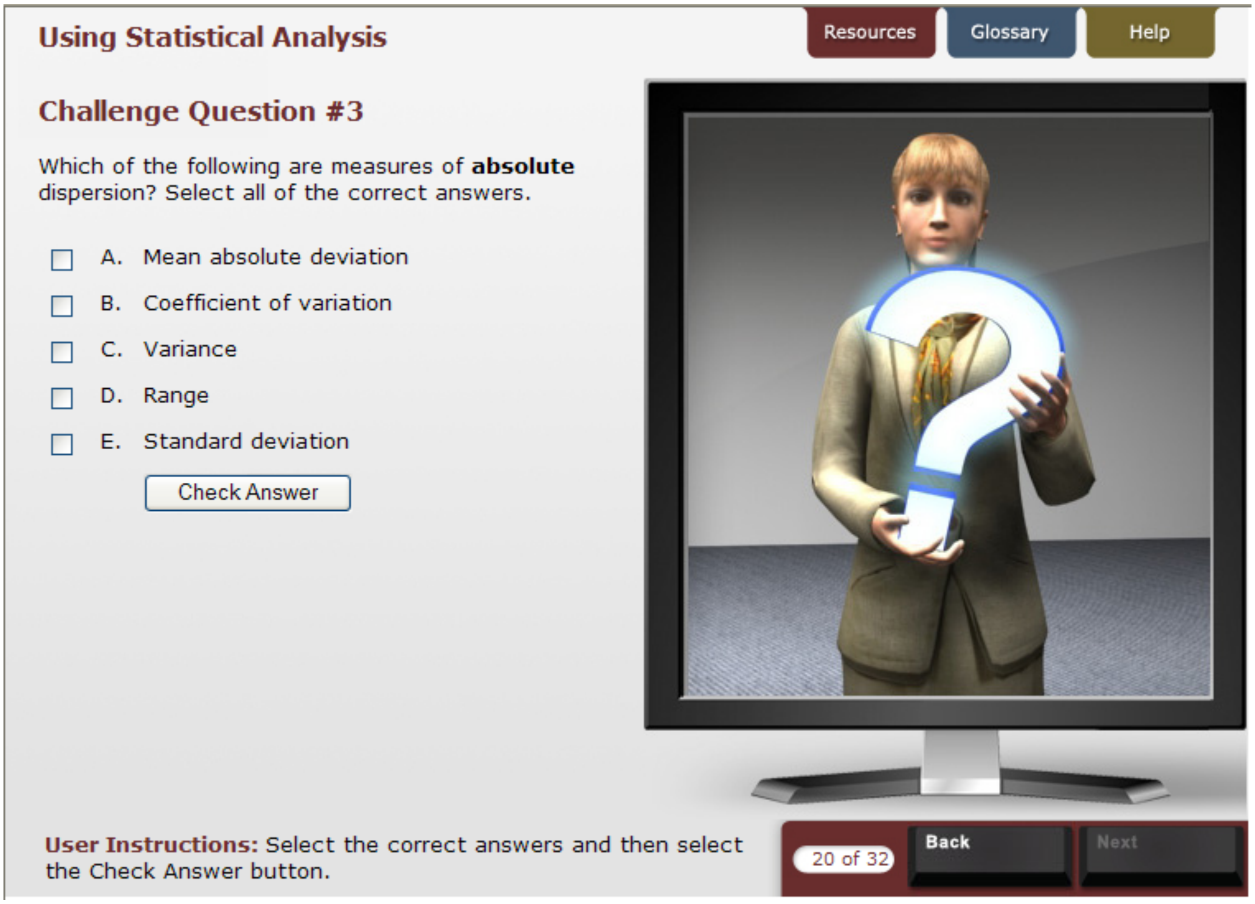
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Challenge Question #3
Which of the following are measures of **absolute** dispersion? Select all of the correct answers.
A. Mean absolute deviation
B. Coefficient of variation
C. Variance
D. Range
E. Standard deviation
Check Answer
User Instructions: Select the correct answers and then select the Check Answer button.
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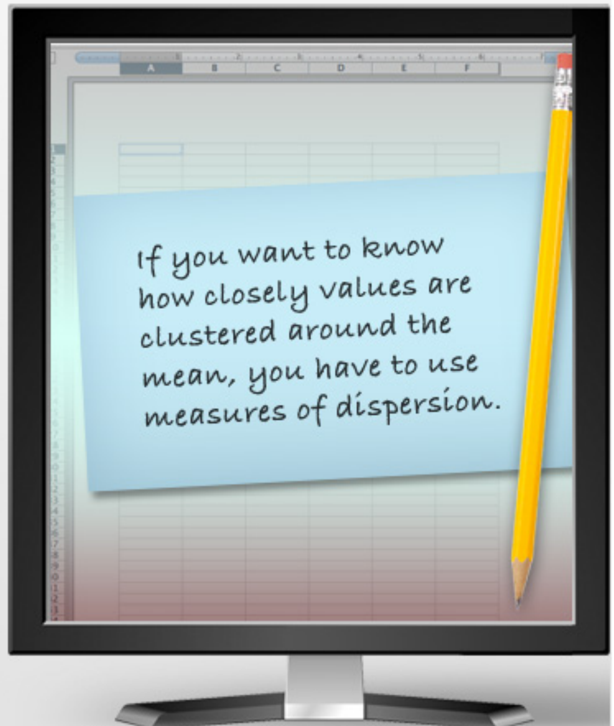
Measures of Dispersion

Remember what you learned about the mean? It is the value around which the other values tend to cluster, but it conveys no indication of the closeness of the clustering or **dispersion**.

We will discuss several measures of **absolute dispersion** - range, mean absolute deviation, variance, and standard deviation.

And one measure of **relative dispersion** - the coefficient of variation.

Let's use the earlier example of scrap rates for Departments A and B to illustrate measures of absolute dispersion.



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Calculating the Range

The **range** of a set of data is the difference between the highest and lowest observed values. The higher the range, the greater the amount of variation in a data set.

R = H - L

Where:

R = Range
H = Highest observed value in the data set
L = Lowest observed value in the data set

$R_{Dept\ A} = .068 - .032$
$= .036$

$R_{Dept\ B} = .053 - .048$
$= .005$

By comparing the range for Department A scrap-rate data with the range for Department B, you can easily determine that the historical data from Department A shows greater dispersion.

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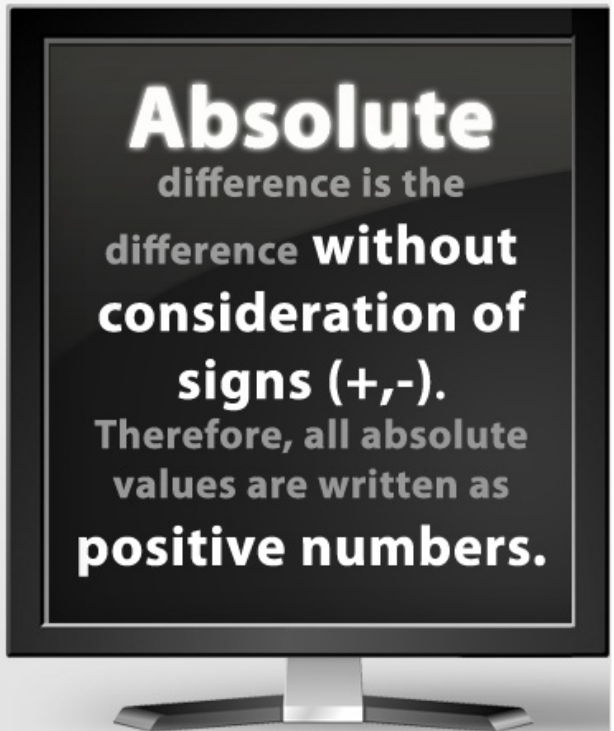
Calculating Mean Absolute Deviation

The **mean absolute deviation** (MAD) is the average absolute difference between the observed values and the arithmetic mean (average) for all values in the data set.

Subtracting the mean from each observation, will give you both positive and negative numbers. The sum of all the deviations will always be zero.

$x - \bar{x}$

However, that tells you nothing about how far the average observation is from the mean.



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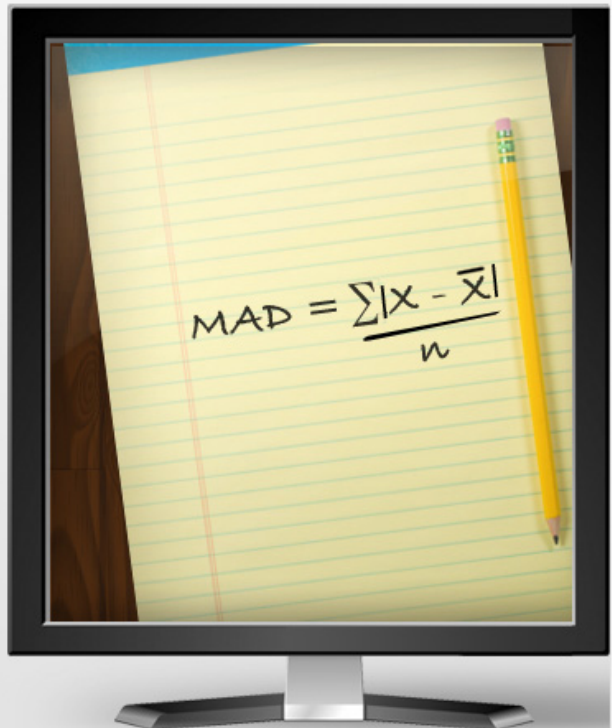
Calculating Mean Absolute Deviation (cont.)

To figure out how far the average observation is from the mean, use the absolute difference between each observation and the mean.

If the average is eight and the observed value is six, the calculated difference is a negative two but the absolute difference would be two.



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Calculating the Mean Absolute Deviation (cont.)

To compute the MAD, use the following 5-step process:

Step 1. Calculate the arithmetic mean of the data set.

Step 2. Calculate the deviation (difference) between each observation and the mean of the data set. If we sum the differences, you will get zero since the values above and below the mean are equal. You can resolve this by using the absolute values.

Step 3. Convert each deviation to its absolute value (i.e., its value without considering the sign of the deviation).

Step 4. Sum the absolute deviations.

Step 5. Divide the total absolute deviation by the number of observations in the data set.

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Calculating the Mean Absolute Deviation (cont.)

We can use the 5-step process described in the previous screen to calculate the scrap-rate MAD values for Departments A and B of the scrap-rate example.

Calculate the MAD for Department A:

Step 1. Calculate the arithmetic mean of the data set. You have already calculated the mean rate for Department A of the scrap-rate example -- .05.

Step 2. Calculate the deviation (difference) between each observation and the mean of the data set.

Department A (Fabrication)		
x	$\bar{x}$	$x - \bar{x}$
.065	.050	.015
.035	.050	-.015
.042	.050	-.008
.058	.050	.008
.032	.050	-.018
.068	.050	.018

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Calculating the Mean Absolute Deviation (cont.)

Step 3. Convert each deviation to its absolute value.

Department A (Fabrication)			
X	$\bar{X}$	$X - \bar{X}$	$\lvert X - \bar{X}\rvert$
.065	.050	.015	.015
.035	.050	-.015	.015
.042	.050	-.008	.008
.058	.050	.008	.008
.032	.050	-.018	.018
.068	.050	.018	.018

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Calculating the Mean Absolute Deviation (cont.)

Step 4. Sum the absolute deviations.

Department A (Fabrication)			
X	**$\bar{X}$**	**$X - \bar{X}$**	**$\lvert X - \bar{X} \rvert$**
.065	.050	.015	.015
.035	.050	-.015	.015
.042	.050	-.008	.008
.058	.050	.008	.008
.032	.050	-.018	.018
.068	.050	.018	.018
		Total	.082

Step 5. Divide the total absolute deviation by the number of observations in the data set.
.082/6 = .014

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Calculating the Mean Absolute Deviation (cont.)

Calculate the MAD for Department B:

Step 1. Calculate the arithmetic mean of the data set. We have also calculated the mean rate for Department B of the scrap-rate example -- .05.

Steps 2 - 4. Calculate the deviation between each observation and the mean of the data set; convert the deviation to its absolute value; and sum the absolute deviations. The following table demonstrates the three steps required to calculate the total absolute deviation for Department B:

Department B (Assembly)			
X	$\bar{X}$	$X - \bar{X}$	$\lvert X - \bar{X} \rvert$
.050	.050	.000	.000
.048	.050	-.002	.002
.052	.050	.002	.002
.053	.050	.003	.003
.048	.050	-.002	.002
.049	.050	-.001	.001
		Total	.010

Step 5. Divide the total absolute deviation by the number of observations in the data set.
.010/6 = .002

User Instructions: Select Next to continue.

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Calculating the Mean Absolute Deviation (cont.)

Compare MAD values for Department A and Department B:

The MAD for Department A is .014; the MAD for Department B is .002.

Note that the MAD for Department B is much smaller than the MAD for Department A.

This comparison once again confirms that there is less dispersion in the observations from Department B.

User Instructions: Select Next to continue.

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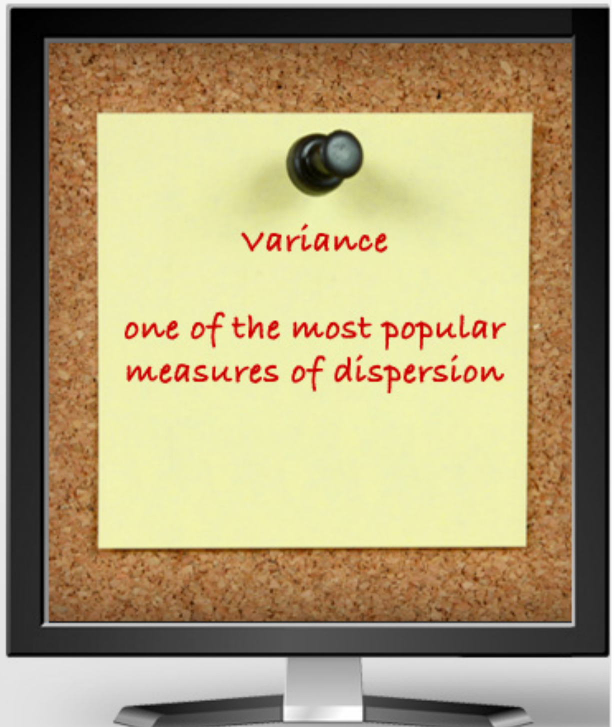
Calculating the Variance

The **variance** of a sample is the average of the squared deviations between each observation and the mean.

$$S^2 = \frac{\Sigma(X - \bar{X})^2}{n - 1}$$

If you have a relatively small sample, you can get a better estimate of the true population variance by dividing the sum of the squared deviations by n - 1, instead of n.

Without this adjustment, the sample variance is likely to underestimate the true variation in the population. While dividing by n - 1 artificially inflates the sample variance, it makes it a better estimator of the population variance.



D

User Instructions: Select Next to continue.

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Calculating the Variance (cont.)

To compute the variance, use this 5-step process:

Step 1. Calculate the arithmetic mean of the data set.

Step 2. Calculate the deviation (difference) between each observation and the mean of the data set. If we sum the differences, we will get zero since the values above and below the mean are equal. We can resolve this issue by squaring the differences.

Step 3. Square each deviation.

Step 4. Sum the squared deviations.

Step 5. Divide the sum of the squared deviations by n - 1.

User Instructions: Select Next to continue.

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Calculating the Variance (cont.)

Calculate the variance for Department A:

Step 1. Calculate the arithmetic mean of the data set. We have already calculated the mean rate for Department A of the scrap-rate example -- .05.

Step 2. Calculate the deviation (difference) between each observation and the mean of the data set ($x - \bar{x}$). The deviations for Department A are the same as we calculated in calculating the mean absolute deviation.

Department A (Fabrication)		
x	$\bar{x}$	$x - \bar{x}$
.065	.050	.015
.035	.050	-.015
.042	.050	-.008
.058	.050	.008
.032	.050	-.018
.068	.050	.018

User Instructions: Select Next to continue.

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Calculating the Variance (cont.)

Step 3. Square each deviation

Department A (Fabrication)			
X	$\bar{X}$	$X - \bar{X}$	$(X - \bar{X})^2$
.065	.050	.015	.000225
.035	.050	-.015	.000225
.042	.050	-.008	.000064
.058	.050	.008	.000064
.032	.050	-.018	.000324
.068	.050	.018	.000324

Step 4. Sum the total absolute deviations

Department A (Fabrication)			
X	$\bar{X}$	$X - \bar{X}$	$(X - \bar{X})^2$
.065	.050	.015	.000225
.035	.050	-.015	.000225
.042	.050	-.008	.000064
.058	.050	.008	.000064
.032	.050	-.018	.000324
.068	.050	.018	.000324
		Total	.001226

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Calculating the Variance (cont.)

Step 5. Divide the sum of the squared deviations by n - 1.

$$S^2 = \frac{\Sigma(X - \bar{X})^2}{n - 1}$$

$$S^2_{DeptA} = .001226/6 - 1$$
$$= .001226/5$$
$$= .00245$$

User Instructions: Select Next to continue.

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Calculating the Variance (cont.)

Calculate the variance for Department B

Step 1. Calculate the arithmetic mean of the data set. We have also calculated the mean rate for Department B of the scrap-rate example -- .05.

Steps 2 - 4. Calculate the deviation between each observation and the mean of the data set; convert the deviation to its absolute value; and sum the absolute deviations. The following table demonstrates the three steps required to calculate the total absolute deviation for Department B:

Department B (Assembly)			
X	$\bar{X}$	$X - \bar{X}$	$(X - \bar{X})^2$
.050	.050	.000	.000000
.048	.050	-.002	.000004
.052	.050	.002	.000004
.053	.050	.003	.000009
.048	.050	-.002	.000004
.049	.050	-.001	.000001

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Calculating the Variance (cont.)

Step 5. Divide the sum of the squared deviations by n-1.

$$S^2 = \frac{\Sigma(X - \bar{X})^2}{n - 1}$$

$$S^2_{DeptB} = .000022/6 - 1$$
$$= .000022/5$$
$$= .000004$$

The variance, for Department A is .000245. The variance for Department B is .000004. Once again, the variance comparison confirms that there is less dispersion in the observations from Department B.

User Instructions: Select Next to continue.

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Using Statistical Analysis

Concerns about Variance

There are two concerns that are commonly raised about using variance as a measure of dispersion:

1. As the deviations between the observations and the mean grow, the variation grows much faster, because all the deviations are squared.

2. The variance is in a different denomination than the values of the data set. For example, if the basic values are measured in terms of feet, the variance is measured in terms of square feet.

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Calculating the Standard Deviation

You can eliminate the concerns about using variation as a measure of dispersion by using **standard deviation** - the square root of the variance.

$S = \sqrt{S^2}$

Because all values are squared, a single observation that is far from the mean can substantially affect both the variance and the standard deviation.

The standard deviation for Departments A and B of the scrap-rate example yields a standard deviation of .015652 for Department A, and .002000 for Department B. The standard deviation is the average estimating error. For Department A, it tells you if you could be off by 1.6%. The greater the standard deviation, the more risk involved in forecasting.

Note: Both the variance and the standard deviation give increasing weight to observations that are further away from the mean. Because all values are squared, a single observation that is far from the mean can substantially affect both the variance and the standard deviation.

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Calculating the Coefficient of Variation

So far, we have only compared two samples with equal means. **But what if the means of two samples are not equal?**

In this situation, you need a measure of relative dispersion - the **coefficient of variation** (CV).

Coefficient of variation is the ratio of the standard deviation to the mean.

$$CV = \frac{S}{\bar{X}}$$

D

User Instructions: Select Next to continue.

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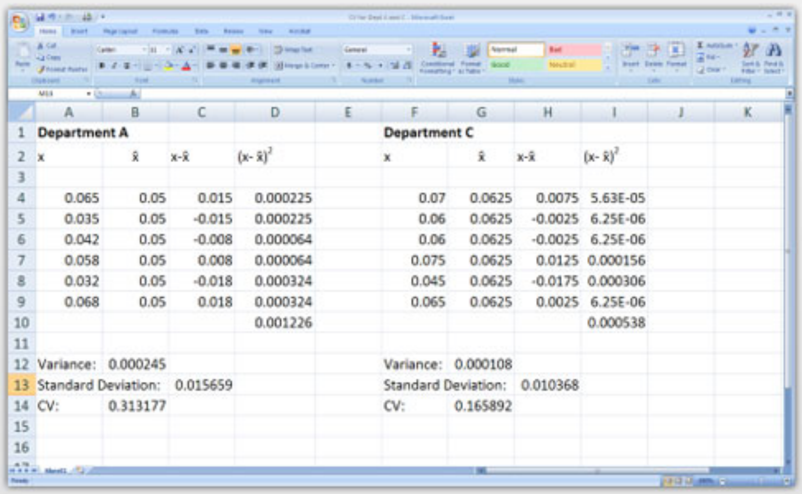
Calculating the Coefficient of Variation (cont.)

Use the data from Departments A and C to compare the CV. The CV for Department A is .3132 and the CV for Department C is .1659.

In the graphic below, CV values demonstrate that the scrap rate for Department C exhibits less relative variation than Department A.



	A	B	C	D	E	F	G	H	I
1	Department A					Department C			
2	x	x̄	x-x̄	$(x-\bar{x})^2$		x	x̄	x-x̄	$(x-\bar{x})^2$
3									
4	0.065	0.05	0.015	0.000225		0.07	0.0625	0.0075	5.63E-05
5	0.035	0.05	-0.015	0.000225		0.06	0.0625	-0.0025	6.25E-06
6	0.042	0.05	-0.008	0.000064		0.06	0.0625	-0.0025	6.25E-06
7	0.058	0.05	0.008	0.000064		0.075	0.0625	0.0125	0.000156
8	0.032	0.05	-0.018	0.000324		0.045	0.0625	-0.0175	0.000306
9	0.068	0.05	0.018	0.000324		0.065	0.0625	0.0025	6.25E-06
10				0.001226					0.000538
11									
12	Variance:	0.000245				Variance:	0.000108		
13	Standard Deviation:		0.015659			Standard Deviation:		0.010368	
14	CV:	0.313177				CV:	0.165892		
15									
16									

User Instructions: Select Next to continue.

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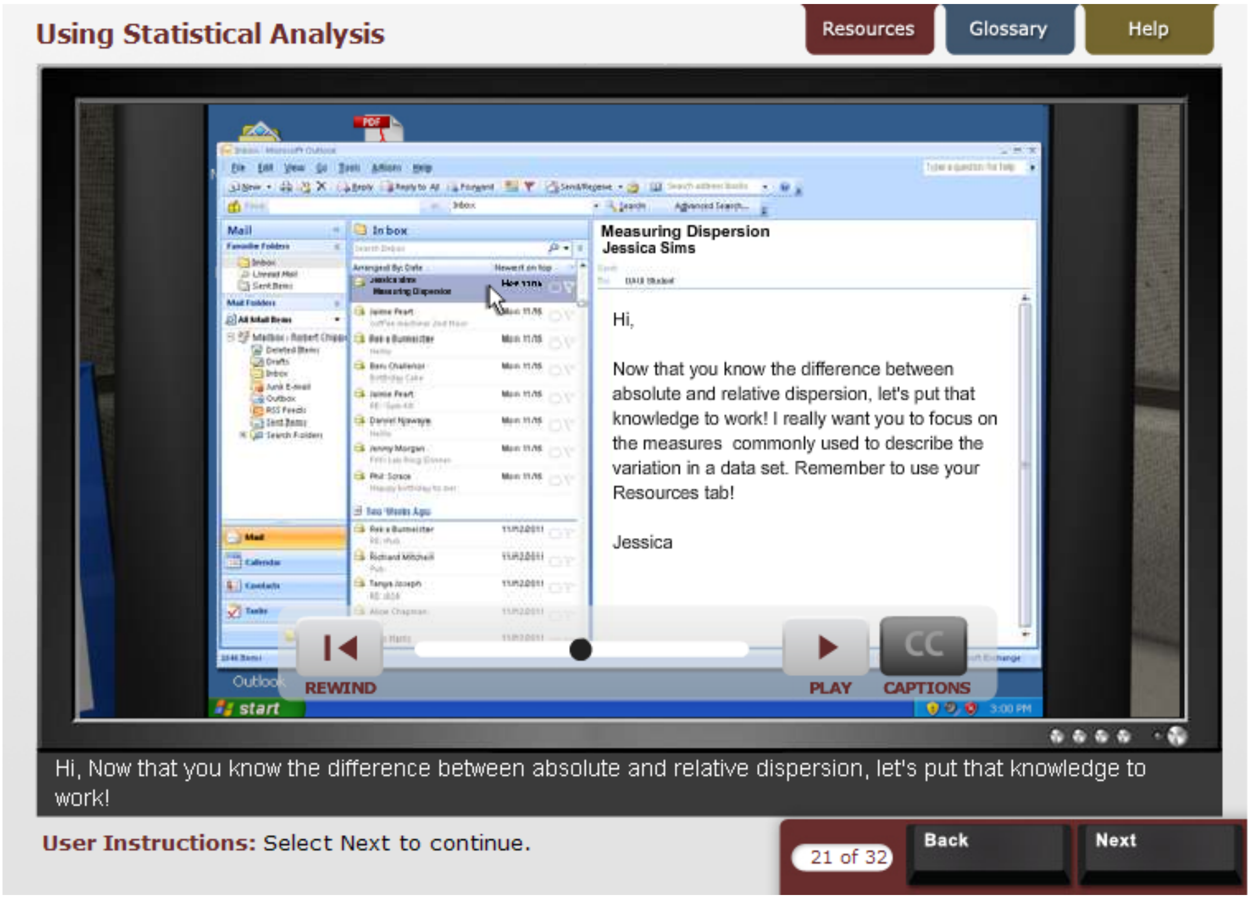
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Measuring Dispersion
Jessica Sims
Hi,
Now that you know the difference between absolute and relative dispersion, let's put that knowledge to work! I really want you to focus on the measures commonly used to describe the variation in a data set. Remember to use your Resources tab!
Jessica
REWIND
PLAY
CAPTIONS
Hi, Now that you know the difference between absolute and relative dispersion, let's put that knowledge to work!
User Instructions: Select Next to continue.
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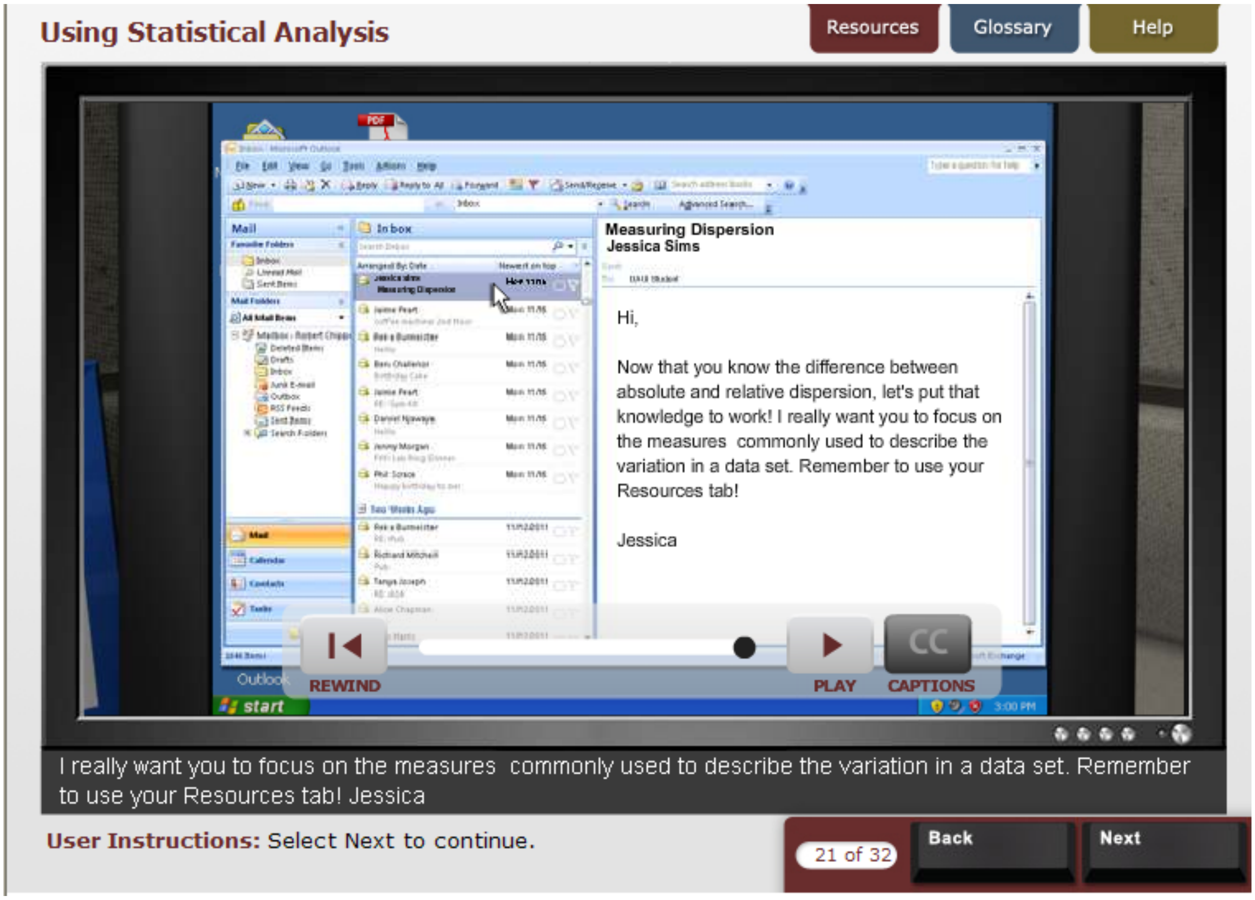
Using Statistical Analysis
Resources
Glossary
Help
Measuring Dispersion
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Hi,
Now that you know the difference between absolute and relative dispersion, let's put that knowledge to work! I really want you to focus on the measures commonly used to describe the variation in a data set. Remember to use your Resources tab!
Jessica
REWIND
PLAY
CAPTIONS
I really want you to focus on the measures commonly used to describe the variation in a data set. Remember to use your Resources tab! Jessica
User Instructions: Select Next to continue.
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Challenge Question #4

What is the **range** for the following numbers?

13, 12, 9, 15, 11, 16, 17, 8, 12, 7, 12

- A. 1
- B. 10
- C. 11
- D. 12

Check Answer

User Instructions: Select the correct answer.

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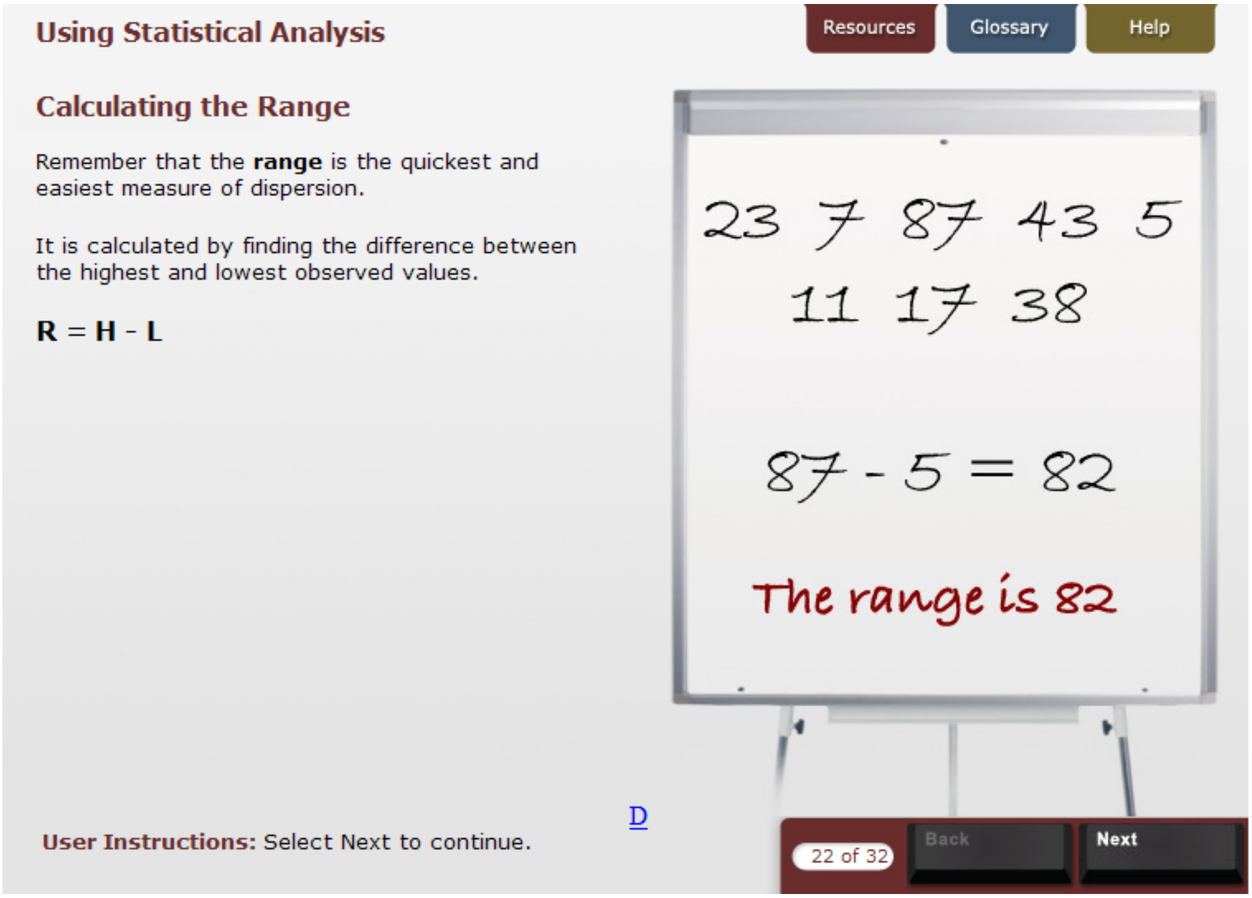
Using Statistical Analysis
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Calculating the Range
Remember that the **range** is the quickest and easiest measure of dispersion.
It is calculated by finding the difference between the highest and lowest observed values.
R = H - L
23 7 87 43 5
11 17 38
87 - 5 = 82
The range is 82
D
User Instructions: Select Next to continue.
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CAPTIONS
Hi, it's Jessica, your Contracting Officer. In contract pricing, it is important to determine a confidence interval, that is, a probability statement about an interval which is likely to contain the true population mean.
User Instructions: Select Next to continue.
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CAPTIONS
If you review the DCAA Auditor's Working Papers, particularly the tab on the sampling methodology, you'll see the auditor selected a 90% confidence level.
User Instructions: Select Next to continue.
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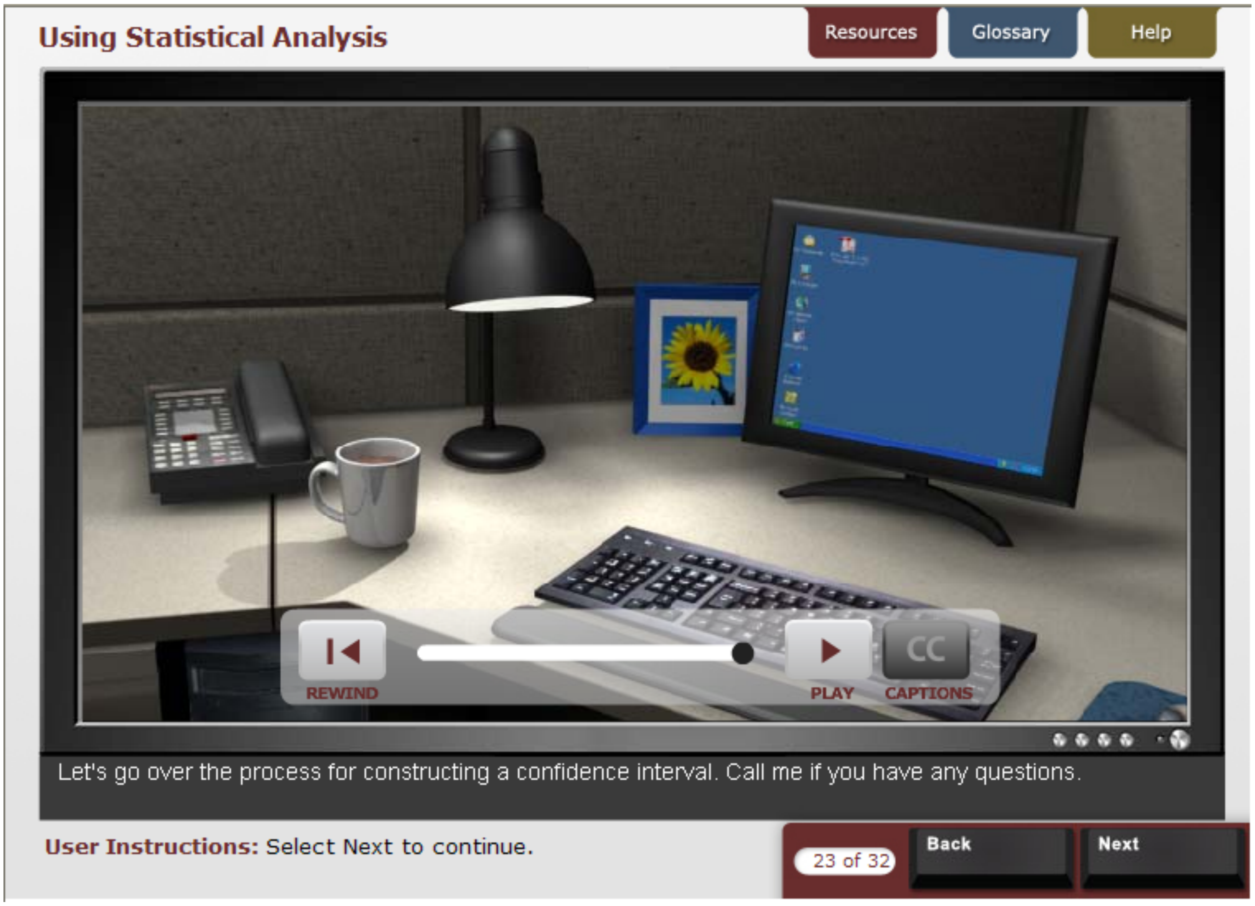
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CAPTIONS
Let's go over the process for constructing a confidence interval. Call me if you have any questions.
User Instructions: Select Next to continue.
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Challenge Question #5

The auditor used a 90% confidence interval when selecting the sample size you just viewed. What does this value indicate? Select all of the correct answers.

- ☐ A. The level of confidence that the true population mean (or average) is contained within the confidence interval.
- ☐ B. That 90 times out of 100, the actual error rate is expected to fall within the confidence interval computed from the sample results.
- ☐ C. That the auditor is accepting a 10% risk that the populations mean is outside of the confidence interval (5% greater or 5% less).
- ☐ D. The significance level is 10%.

Check Answer

User Instructions: Select the correct answers and then select the Check Answer button.

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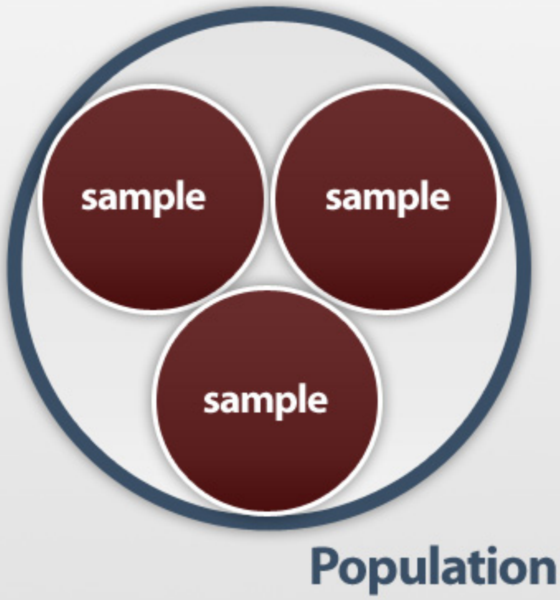
Establishing a Confidence Interval

Each time you take a sample from a population of values you can calculate a mean and a standard deviation.

Even if all of the samples are the same size and are taken using the same random procedures, it is unlikely that every sample will have the same mean and standard deviation.

However, if you could collect each sample from the normally distributed population and calculate the mean value for all the sample means, the result would be equal to the population mean.



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User Instructions: Select Next to continue.

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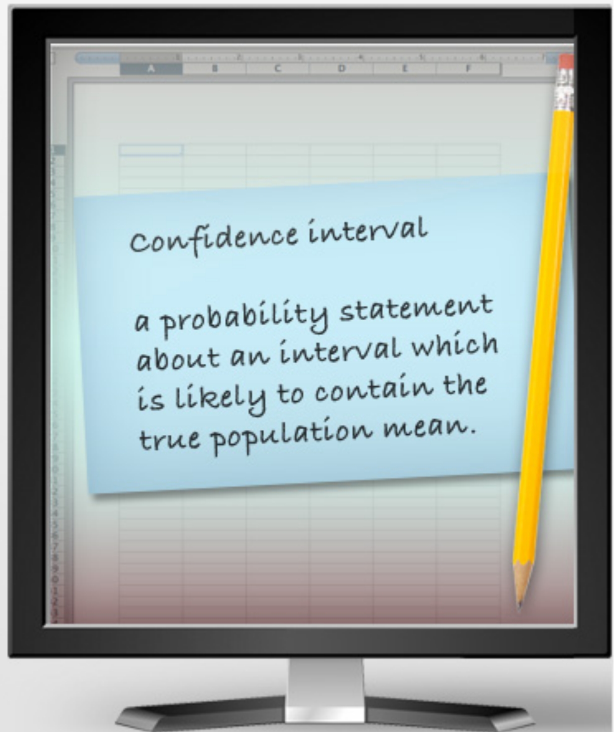
Establishing a Confidence Interval (cont.)

In statistical terms, the mean of the sampling distribution is equal to the population mean.

You can establish a **confidence interval** using the sample mean, the standard error of the mean, and an understanding of the normal probability distribution and the t distribution.



D

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Standard Error of the Mean

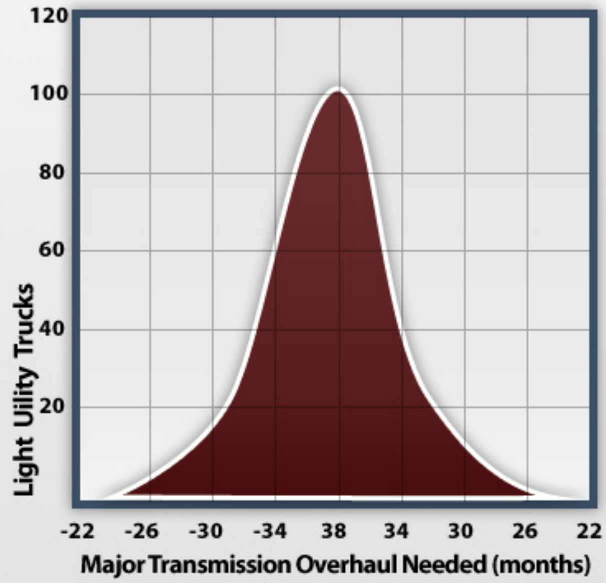
If the population is normally distributed, the standard error of the mean is equal to the population standard deviation divided by the square root of sample size.

Since we normally do not know the population standard deviation, we use the sample standard deviation to estimate the population standard deviation.

$$S_{\bar{x}} = \frac{S}{\sqrt{n}}$$

Because the population mean and the population standard deviation are not normally known, we **assume** that cost or pricing information is equally distributed.

This is a critical assumption because it allows us to construct confidence intervals (negotiation ranges) around point estimates (government objectives).



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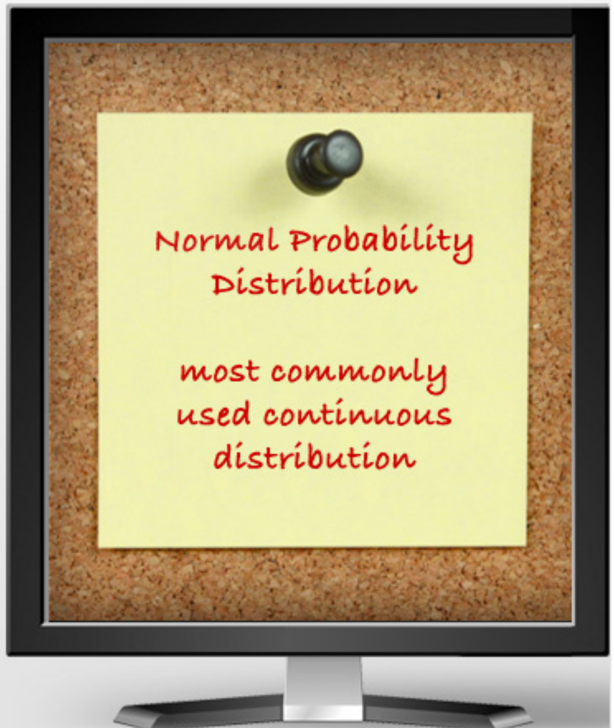
Normal Probability Distribution

Normal probability distribution is a close approximation of the distribution of such things as the output of manufacturing processes.

It provides the probability of a continuous random variable, and has the following characteristics:

- It is a symmetrical (mean, median, and mode are equal) distribution and half of the possible outcomes are on each side of the mean.
- The total area under the normal curve is equal to 1.00, which means there is a 100% probability that the possible observations drawn from the population will be covered by the normal curve.



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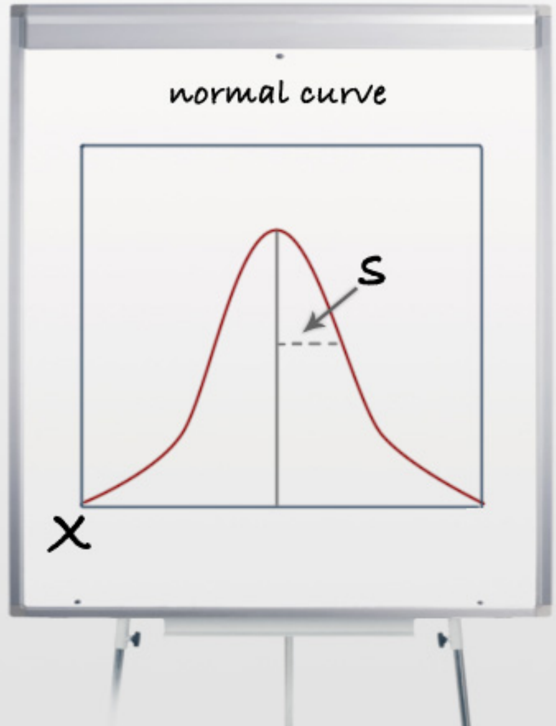
Normal Probability Distribution (cont.)

Here are a few more characteristics of normal probability distribution:

- It is an asymptotic distribution, meaning the tails approach the horizontal axis but never touch it.
- It is represented by a smooth, unimodal, bell-shaped curve, usually called a **normal curve**.
- It can be defined by two characteristics - the mean and the standard deviation.



D

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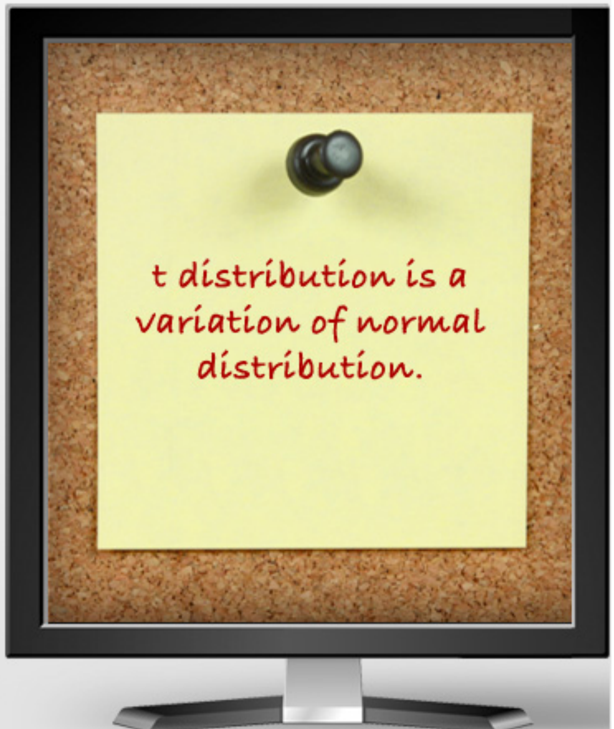
Conditions for Using a Normal Probability Distribution

You can use the normal curve to construct confidence intervals around a sample mean when you know the population mean and standard deviation.

In contract pricing, we typically deal with small sample sizes. In this case, we use a variation of the normal probability distribution, the **t distribution**.



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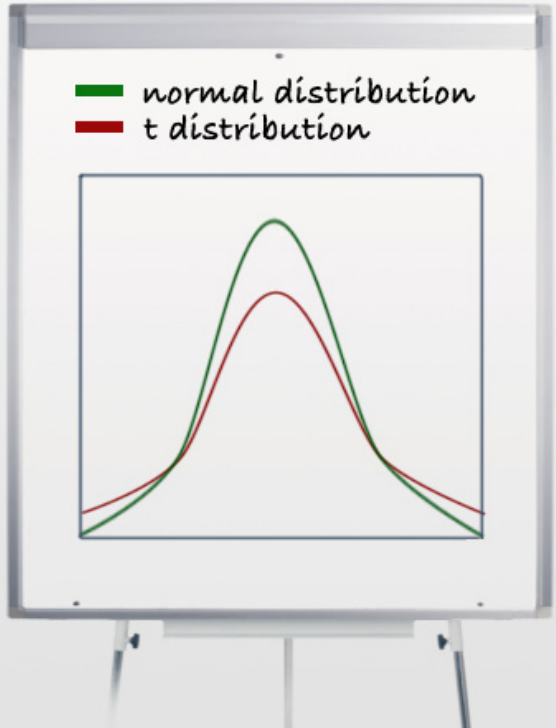
t Distribution

The t distribution has the following characteristics:

- It is symmetrical, like the normal distribution, but it is a flatter curve.
- It is defined by degrees of freedom.
- There is a different t distribution for each sample size.
- As the sample size increases, the shape of the t distribution approaches the shape of the normal distribution.



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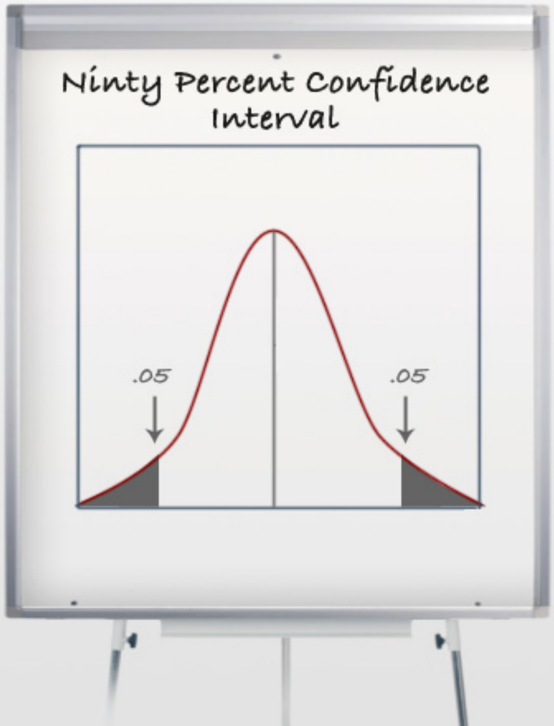
Setting the Significance Level

When setting the significance level, you must determine the amount of risk you are willing to accept that the confidence interval does not include the true population mean.

As the amount of risk that you are willing to accept decreases, the confidence interval will increase.

Your tolerance for risk may vary from situation to situation, but for most pricing decisions, a significance level of .10 is appropriate.



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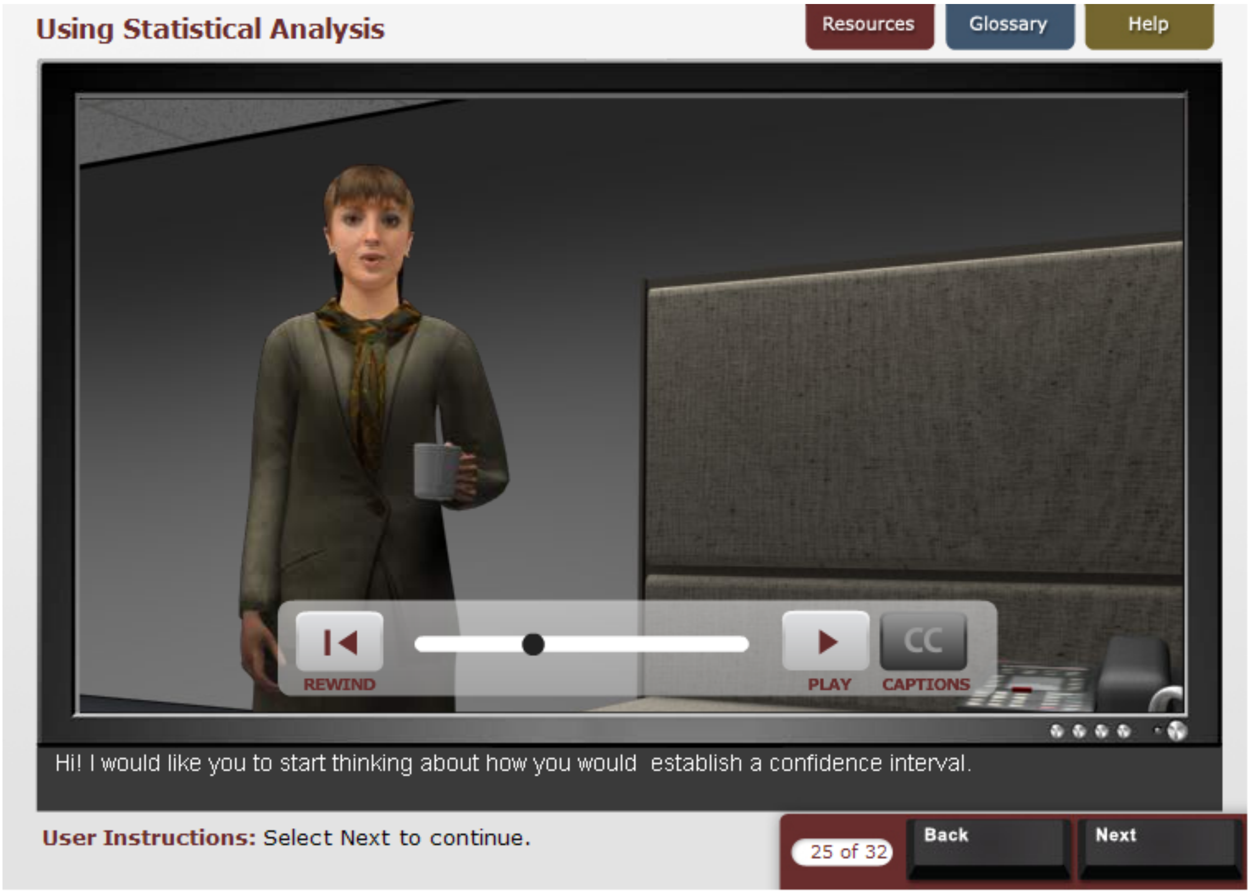
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CAPTIONS
Hi! I would like you to start thinking about how you would establish a confidence interval.
User Instructions: Select Next to continue.
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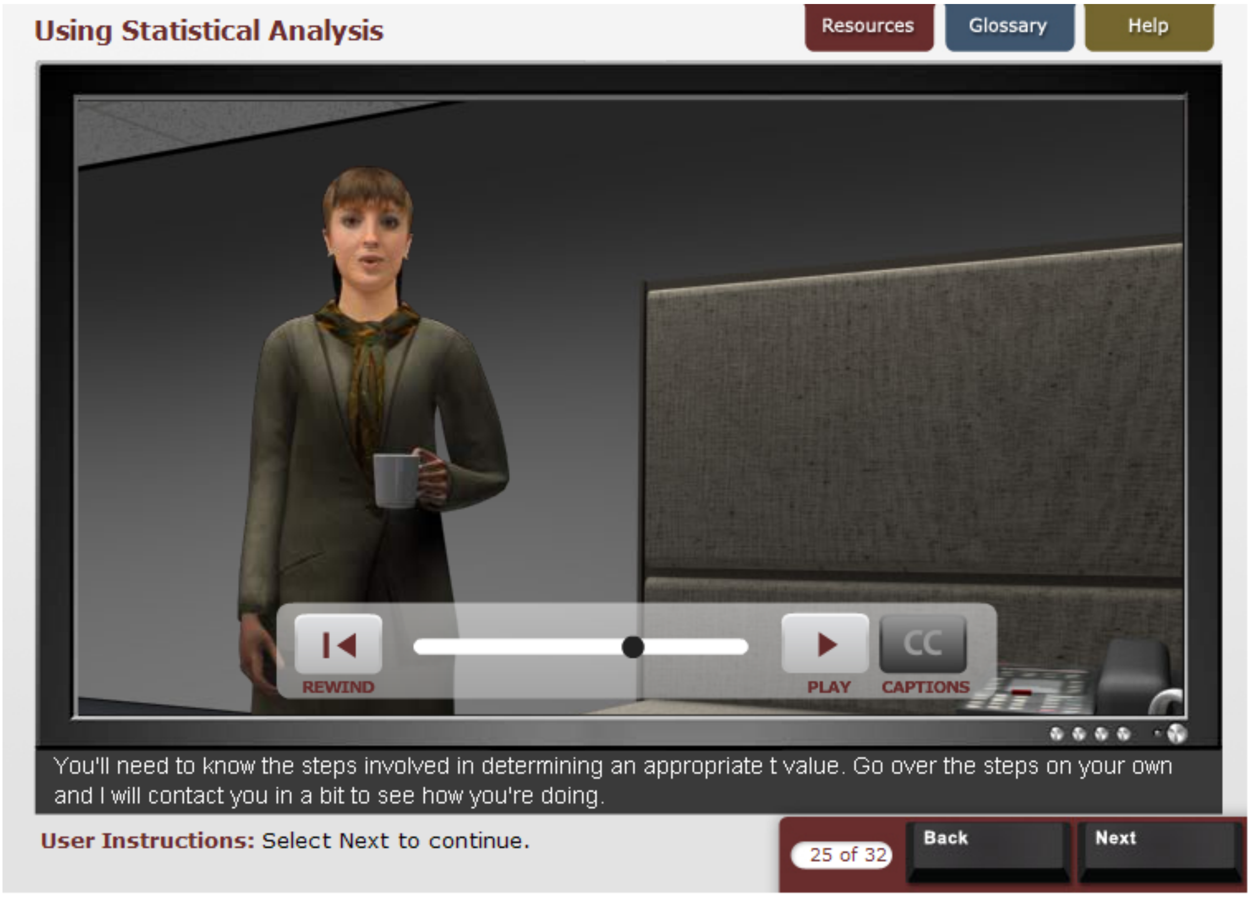
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CAPTIONS
You'll need to know the steps involved in determining an appropriate t value. Go over the steps on your own and I will contact you in a bit to see how you're doing.
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Determining the t Value

There are three steps involved in obtaining the appropriate t value:

Determine your desired significance level. Remember that a significance level of .10 is appropriate for most contract pricing situations. That will provide a confidence level of .90 (1.00 - .10 = .90).

Determine the degrees of freedom. Degrees of freedom (df) is the sample size minus one (n - 1).

Determine the t value from the t Table. Find the t value at the intersection of the df row and the .10 column.

Partial t Table

df	t
------------------------------	------------------------------
23	1.714
24	1.711
25	1.708
26	1.706
------------------------------	------------------------------

User Instructions: Select Next to continue.

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CAPTIONS
Hi, it's Jessica again. I want you to take another look at the DCAA Auditor's Working Papers and the Audit Report.
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CAPTIONS
Can you figure out how the auditor arrived at the 2% decrement factor for the bill of materials? Call me if you have any questions. Bye!
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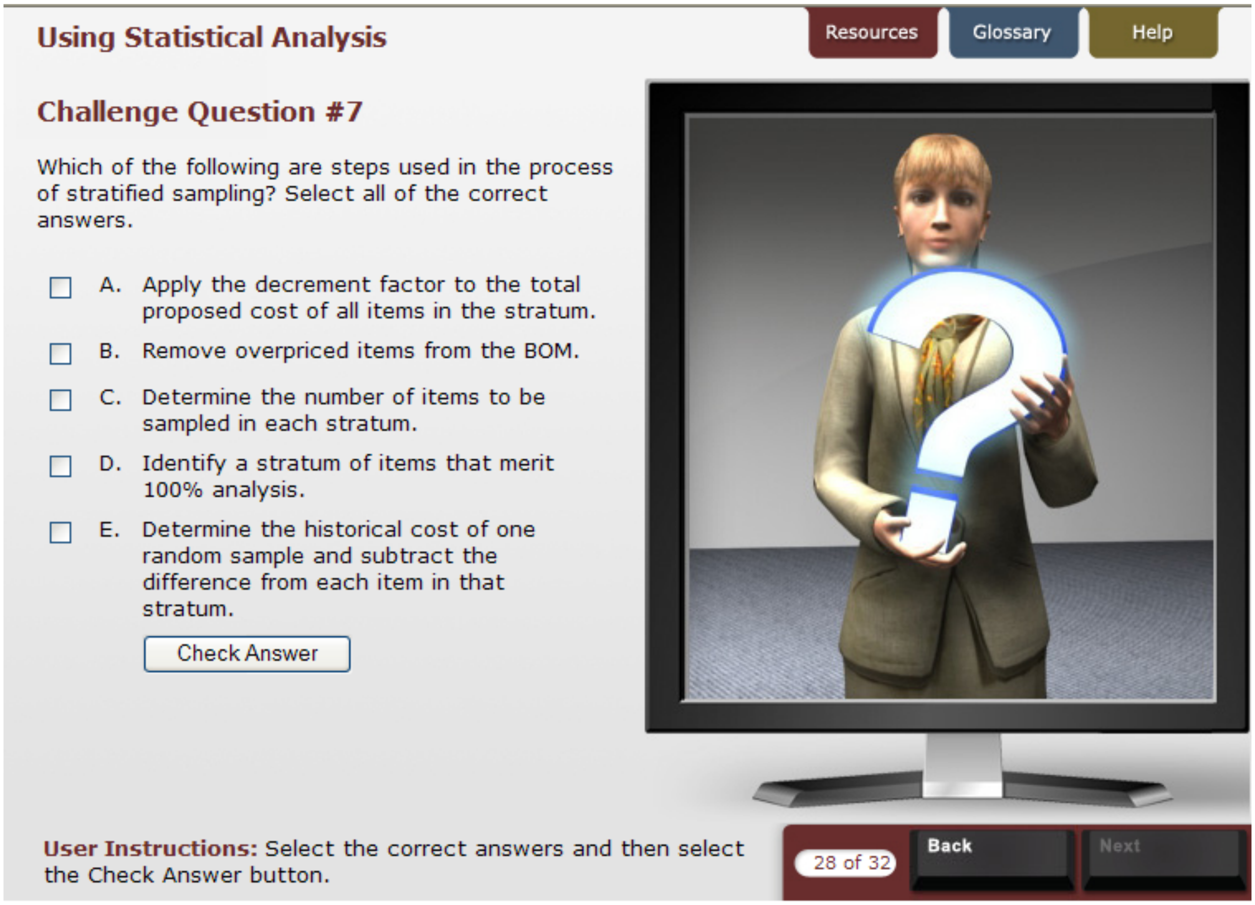
Using Statistical Analysis
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Challenge Question #7
Which of the following are steps used in the process of stratified sampling? Select all of the correct answers.
A. Apply the decrement factor to the total proposed cost of all items in the stratum.
B. Remove overpriced items from the BOM.
C. Determine the number of items to be sampled in each stratum.
D. Identify a stratum of items that merit 100% analysis.
E. Determine the historical cost of one random sample and subtract the difference from each item in that stratum.
Check Answer
User Instructions: Select the correct answers and then select the Check Answer button.
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Steps in Stratified Sampling

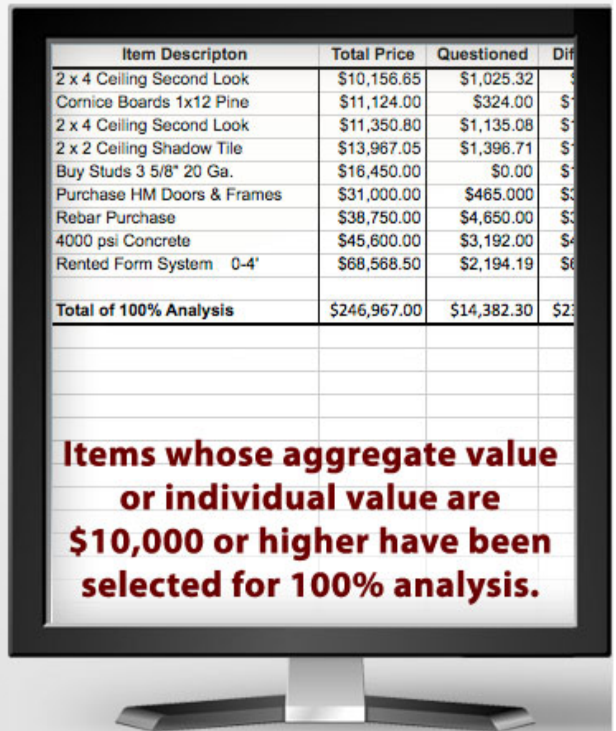
In stratified sampling, the components of the proposed cost, like the BoM in the BBOMS Dining Hall Proposal in your Resources tab for example, are divided into two or more groups (strata) to be analyzed.

One stratum, usually high-value items, is identified for 100% review while the remaining strata are analyzed on a sample basis.

Start here to develop a negotiation position based on stratified sampling:

- Identify a stratum of items that merit 100% analysis.

See the results of the 100% Analysis tab in the DCAA Auditor's Working Papers located in the Resources tab.



Item Descripton	Total Price	Questioned	Dif
2 x 4 Ceiling Second Look	$10,156.65	$1,025.32	$
Cornice Boards 1x12 Pine	$11,124.00	$324.00	$1
2 x 4 Ceiling Second Look	$11,350.80	$1,135.08	$1
2 x 2 Ceiling Shadow Tile	$13,967.05	$1,396.71	$1
Buy Studs 3 5/8" 20 Ga.	$16,450.00	$0.00	$1
Purchase HM Doors & Frames	$31,000.00	$465.000	$3
Rebar Purchase	$38,750.00	$4,650.00	$3
4000 psi Concrete	$45,600.00	$3,192.00	$4
Rented Form System 0-4'	$68,568.50	$2,194.19	$6
Total of 100% Analysis	$246,967.00	$14,382.30	$2

D

User Instructions: Select Next to continue.

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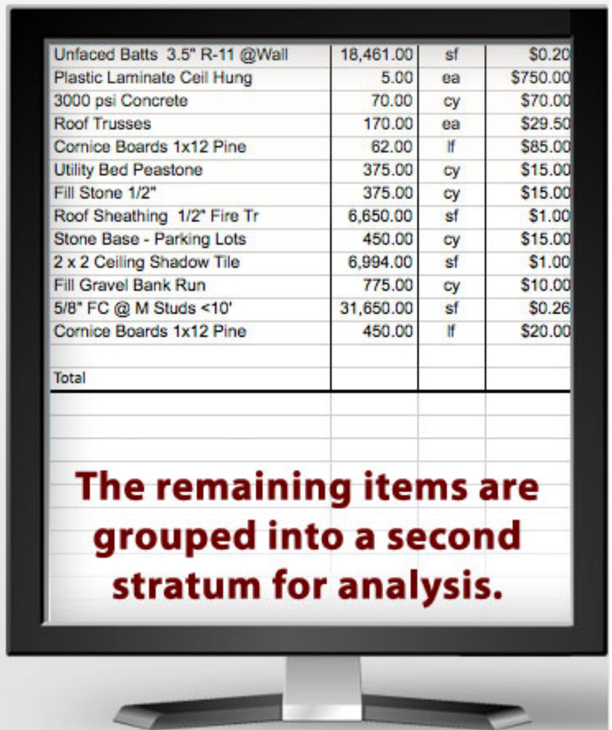
Using Statistical Analysis

Steps in Stratified Sampling (cont.)

Next, you want to:

- Group the remaining items into one or more stratum for analysis.

See the BoM Second Stratum tab in your DCAA Auditor's Working Papers spreadsheet located under Resources.



Unfaced Batts 3.5" R-11 @Wall	18,461.00	sf	$0.20
Plastic Laminate Ceil Hung	5.00	ea	$750.00
3000 psi Concrete	70.00	cy	$70.00
Roof Trusses	170.00	ea	$29.50
Cornice Boards 1x12 Pine	62.00	lf	$85.00
Utility Bed Peastone	375.00	cy	$15.00
Fill Stone 1/2"	375.00	cy	$15.00
Roof Sheathing 1/2" Fire Tr	6,650.00	sf	$1.00
Stone Base - Parking Lots	450.00	cy	$15.00
2 x 2 Ceiling Shadow Tile	6,994.00	sf	$1.00
Fill Gravel Bank Run	775.00	cy	$10.00
5/8" FC @ M Studs <10'	31,650.00	sf	$0.26
Cornice Boards 1x12 Pine	450.00	lf	$20.00
Total			

D

User Instructions: Select Next to continue.

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Using Statistical Analysis

Steps in Stratified Sampling (cont.)

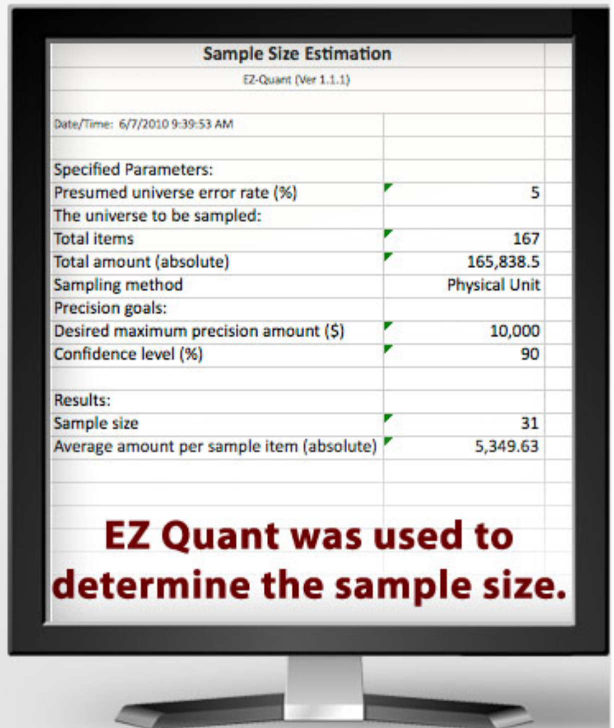
After that, you should:

- Determine the number of items to be sampled in each stratum.

How do you determine the sample size?

You should consider several factors in determining sample size. The primary ones are variability, desired confidence, and the total count of items in the stratum. Use statistical tables or computer programs to determine the proper sample size for each stratum. One such computer program is EZ Quant used by DCAA.

See the sample size selected in the DCAA Auditor's Working Papers Sample Size Estimation worksheet.



Sample Size Estimation

EZ-Quant (Ver 1.1.1)

Date/Time: 6/7/2010 9:39:53 AM	
Specified Parameters:	
Presumed universe error rate (%)	5
The universe to be sampled:	
Total items	167
Total amount (absolute)	165,838.5
Sampling method	Physical Unit
Precision goals:	
Desired maximum precision amount ($)	10,000
Confidence level (%)	90
Results:	
Sample size	31
Average amount per sample item (absolute)	5,349.63

D

User Instructions: Select Next to continue.

Resources Glossary Help

Using Statistical Analysis

Steps in Stratified Sampling (cont.)

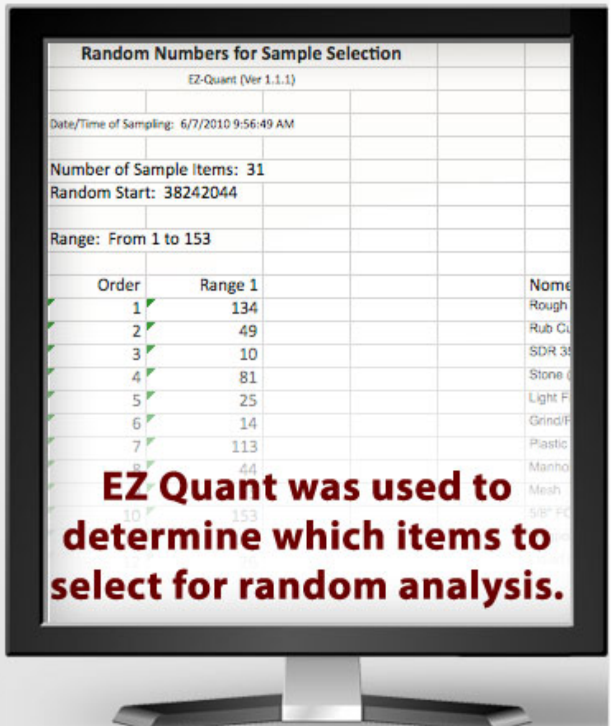
The next step is to:

- Select random items for analysis.

How do you determine which items to select for analysis?

In the strata requiring random sampling, each item in the stratum must have an equal chance of being selected and each item must only be selected once for analysis. Assign each item in the population a sequential number (e.g., 1, 2, 3; or 1001, 1002, 1003). Use a table of random numbers or computer generated random numbers to identify the item numbers to be included in the sample.

EZ Quant, used by the DCAA, will generate random numbers for sample selection. See the random numbers used by the auditor in the DCAA Auditor's Working Papers under the Random Number Sample Sel tab.



D

User Instructions: Select Next to continue.

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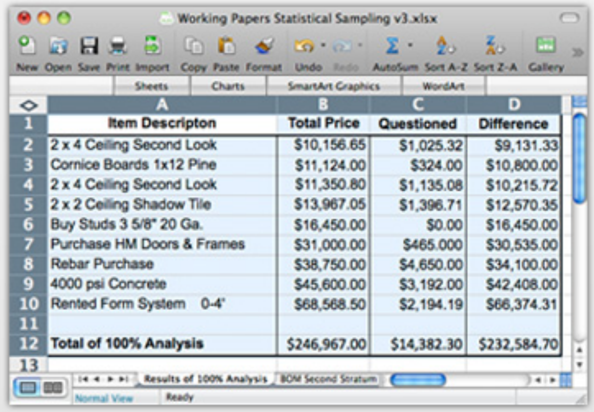
Steps in Stratified Sampling (cont.)

After you select your random items for analysis, you should:

- Analyze all items identified for analysis summing recommended costs for the 100% analysis stratum and developing a decrement factor for any stratum being randomly sampled.



Working Papers Statistical Sampling v3.xlsx

	A	B	C	D
1	Item Descripton	Total Price	Questioned	Difference
2	2 x 4 Ceiling Second Look	$10,156.65	$1,025.32	$9,131.33
3	Cornice Boards 1x12 Pine	$11,124.00	$324.00	$10,800.00
4	2 x 4 Ceiling Second Look	$11,350.80	$1,135.08	$10,215.72
5	2 x 2 Ceiling Shadow Tile	$13,967.05	$1,396.71	$12,570.35
6	Buy Studs 3 5/8" 20 Ga.	$16,450.00	$0.00	$16,450.00
7	Purchase HM Doors & Frames	$31,000.00	$465.000	$30,535.00
8	Rebar Purchase	$38,750.00	$4,650.00	$34,100.00
9	4000 psi Concrete	$45,600.00	$3,192.00	$42,408.00
10	Rented Form System 0-4'	$68,568.50	$2,194.19	$66,374.31
11				
12	Total of 100% Analysis	$246,967.00	$14,382.30	$232,584.70
13				

Take a look at the DCAA Audit Report and the DCAA Auditor's Working Papers Results of 100% Analysis worksheet.

The total of the nine items selected for 100% analysis is $246,967. The auditor questioned $14,382.30 of this amount for an objective of $232,584.70, stating, "Items in excess of $10,000 were analyzed including a review of vendor quotes, subcontractor quotes, inventory records, and purchase orders."

D

User Instructions: Select Next to continue.

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Using Statistical Analysis

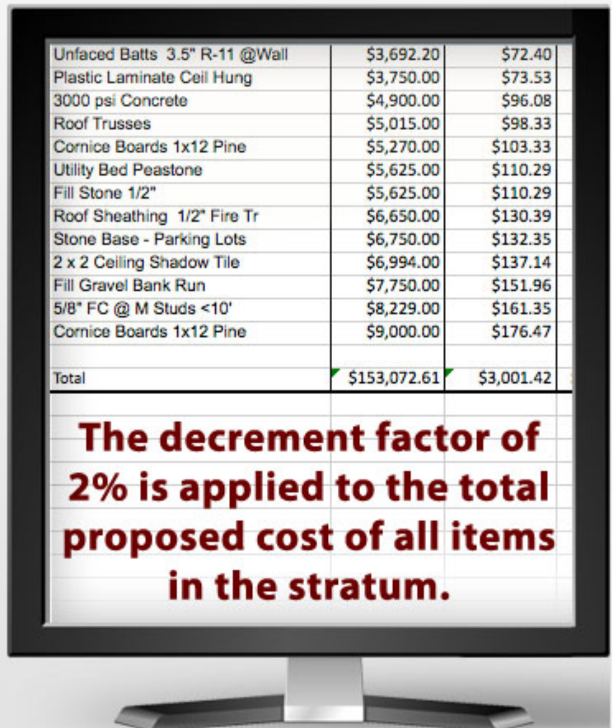
Steps in Stratified Sampling (cont.)

After that, you should:

- Apply the decrement factor to the total proposed cost of all items in the stratum.

See the DCAA Audit Report and the DCAA Auditor's Working Papers Results of Statistical Sampling worksheet.

The auditor applied the 2% decrement factor, stating, "Associated historical costs for each item chosen from the random sample were regressed using a simple regression table. Results of this examination revealed that material costs were overstated by approximately 2%. Based on this analysis, we are questioning 2% of all proposed material costs within the sample."



Unfaced Batts 3.5" R-11 @Wall	$3,692.20	$72.40
Plastic Laminate Ceil Hung	$3,750.00	$73.53
3000 psi Concrete	$4,900.00	$96.08
Roof Trusses	$5,015.00	$98.33
Cornice Boards 1x12 Pine	$5,270.00	$103.33
Utility Bed Peastone	$5,625.00	$110.29
Fill Stone 1/2"	$5,625.00	$110.29
Roof Sheathing 1/2" Fire Tr	$6,650.00	$130.39
Stone Base - Parking Lots	$6,750.00	$132.35
2 x 2 Ceiling Shadow Tile	$6,994.00	$137.14
Fill Gravel Bank Run	$7,750.00	$151.96
5/8" FC @ M Studs <10'	$8,229.00	$161.35
Cornice Boards 1x12 Pine	$9,000.00	$176.47
Total	$153,072.61	$3,001.42

D

User Instructions: Select Next to continue.

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Using Statistical Analysis

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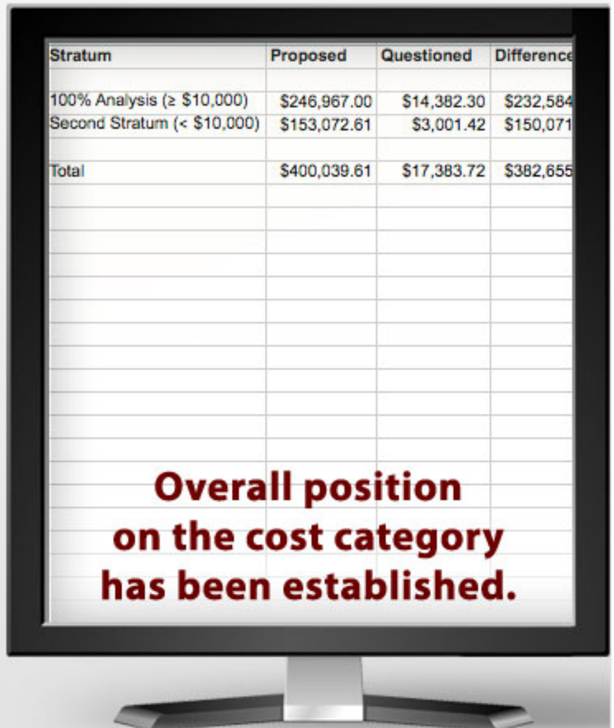
Steps in Stratified Sampling (cont.)

And the last step in stratified sampling is to:

- Total prenegotiation positions for all strata to establish your overall position on the cost category.

See the DCAA Audit Report and the DCAA Auditor's Working Papers Raw Materials and Purchased Parts worksheet.

The total prenegotiation objective for PP and RM is $382,655.89.



Stratum	Proposed	Questioned	Differenc
100% Analysis (≥ $10,000)	$246,967.00	$14,382.30	$232,584
Second Stratum (< $10,000)	$153,072.61	$3,001.42	$150,071
Total	$400,039.61	$17,383.72	$382,655

D

User Instructions: Select Next to continue.

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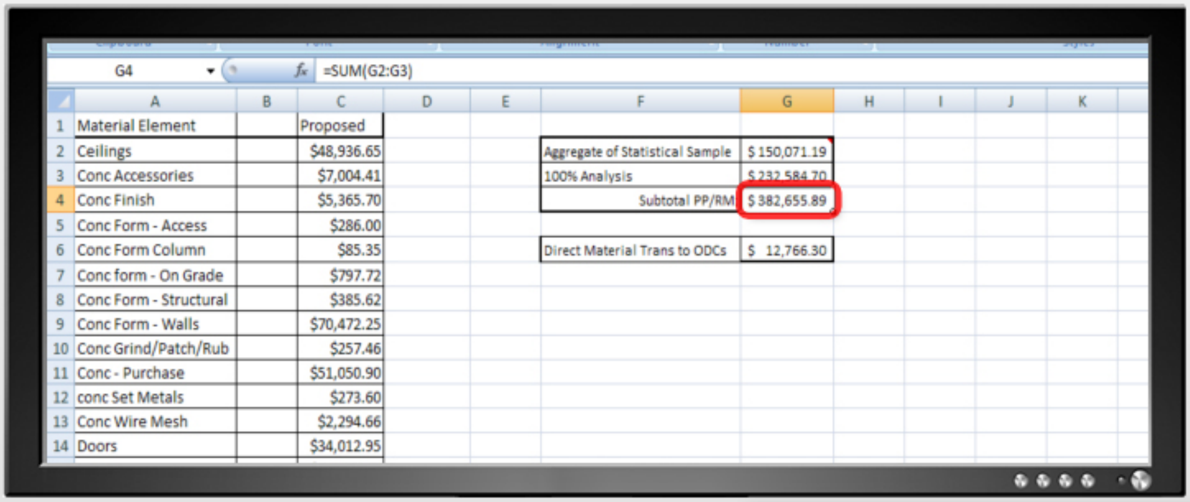
Prenegotiation Amount

This prenegotiation amount is what is entered into your Berent's Dining Hall spreadsheet under the BoM Analysis tab.



G4 =SUM(G2:G3)

	A	B	C	D	E	F	G
1	Material Element		Proposed				
2	Ceilings		$48,936.65			Aggregate of Statistical Sample	$ 150,071.19
3	Conc Accessories		$7,004.41			100% Analysis	$ 232,584.70
4	Conc Finish		$5,365.70			Subtotal PP/RM	$ 382,655.89
5	Conc Form - Access		$286.00				
6	Conc Form Column		$85.35			Direct Material Trans to ODCs	$ 12,766.30
7	Conc form - On Grade		$797.72				
8	Conc Form - Structural		$385.62				
9	Conc Form - Walls		$70,472.25				
10	Conc Grind/Patch/Rub		$257.46				
11	Conc - Purchase		$51,050.90				
12	conc Set Metals		$273.60				
13	Conc Wire Mesh		$2,294.66				
14	Doors		$34,012.95				

User Instructions: Select Next to continue.

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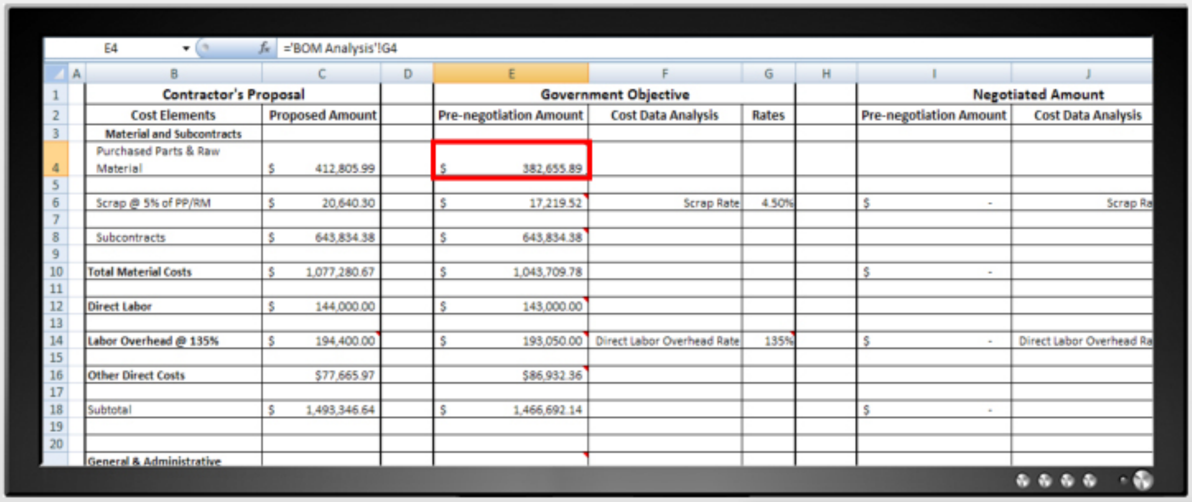
Prenegotiation Amount (cont.)

The amount in cell G4 automatically populates the amount for PP and RM on the summary sheet in cell E4.



E4 | =’BOM Analysis’!G4

	A	B	C	D	E	F	G	H	I	J
1		Contractor's Proposal			Government Objective				Negotiated Amount	
2		Cost Elements	Proposed Amount		Pre-negotiation Amount	Cost Data Analysis	Rates		Pre-negotiation Amount	Cost Data Analysis
3		Material and Subcontracts								
4		Purchased Parts & Raw Material	$ 412,805.99		$ 382,655.89					
5										
6		Scrap @ 5% of PP/RM	$ 20,640.30		$ 17,219.52	Scrap Rate	4.50%		$ -	Scrap Ra
7										
8		Subcontracts	$ 643,834.38		$ 643,834.38					
9										
10		Total Material Costs	$ 1,077,280.67		$ 1,043,709.78				$ -	
11										
12		Direct Labor	$ 144,000.00		$ 143,000.00					
13										
14		Labor Overhead @ 135%	$ 194,400.00		$ 193,050.00	Direct Labor Overhead Rate	135%		$ -	Direct Labor Overhead Ra
15										
16		Other Direct Costs	$77,665.97		$86,932.36					
17										
18		Subtotal	$ 1,493,346.64		$ 1,466,692.14				$ -	
19										
20										
		General & Administrative								

User Instructions: Select Next to continue.

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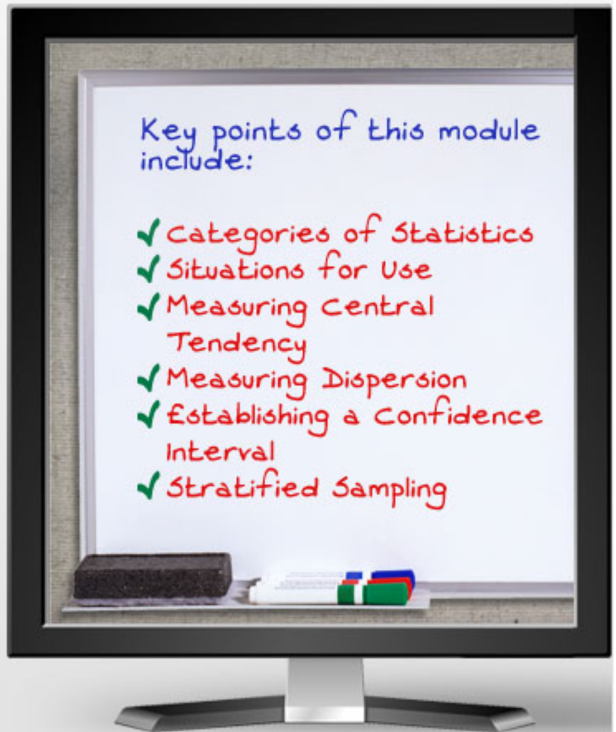
Using Statistical Analysis

Summary

Congratulations! You have completed this module that discussed using statistical analysis and identifying situations where statistical analysis would be appropriate.

Review the graphic on the right to see the key points for this module.



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Using Statistical Analysis

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Summary (cont.)

Now that you have completed this module, you should be able to:

- Identify contract situations where statistical analysis is an appropriate tool for developing a prenegotiation objective
- Differentiate between the measures of central tendency and the methods for measuring dispersion
- Identify the process for establishing a confidence interval
- Identify the process for using stratified sampling
- Calculate a prenegotiation objective using the appropriate statistical analysis techniques

User Instructions: Select the next module from the Table of Contents to continue.

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