Using Improvement Curves

Resources | Glossary | Help

Module Introduction

Welcome to Using Improvement Curves!

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

Learning improvement curve concepts and their application to cost and price analysis will benefit you as a contract specialist.

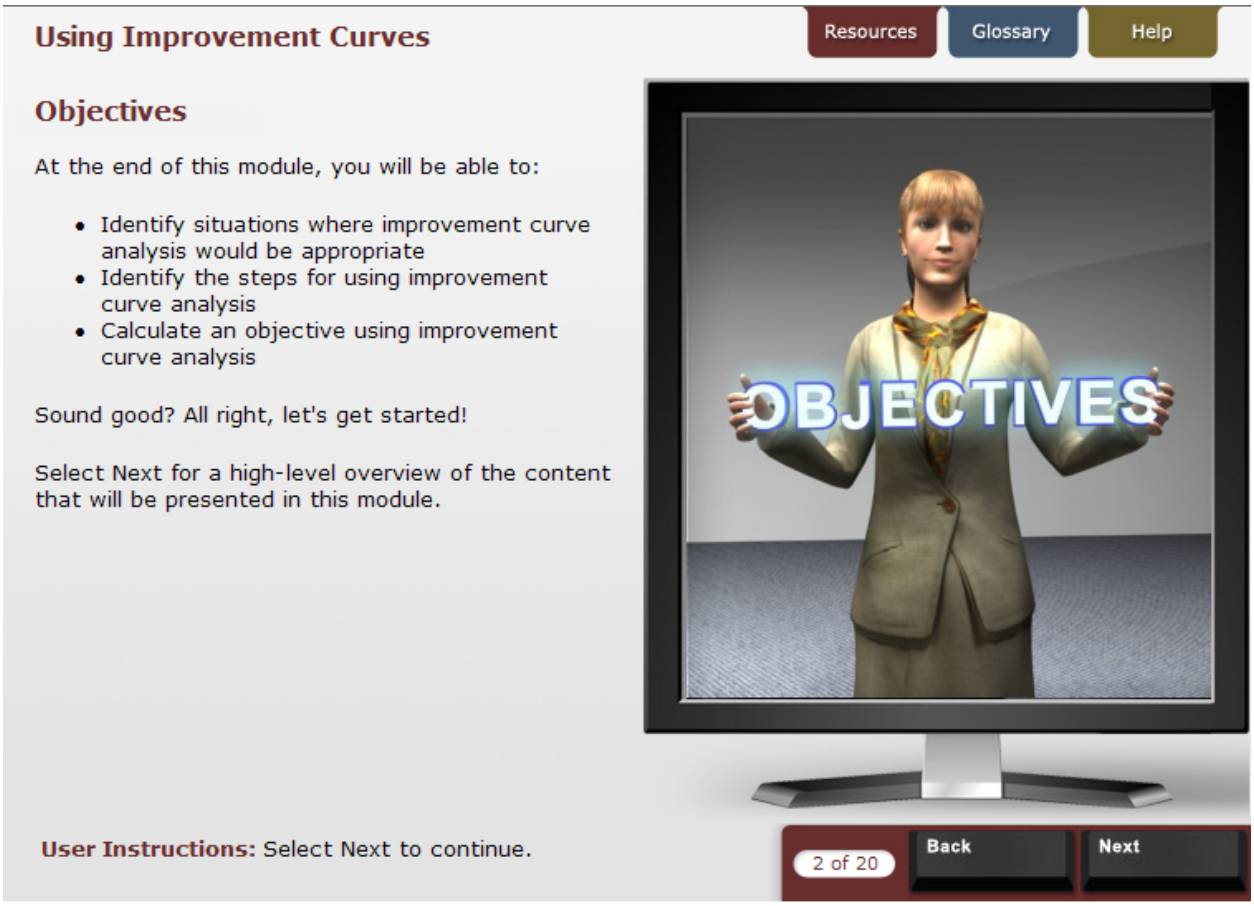
Did you know that a decline in unit cost can be predicted mathematically? As a result, improvement curves can be used to estimate contract price, direct labor-hours, direct material cost, or any other recurring contract cost.

The concept behind improvement curves is to emphasize the need for efforts by the entire organization to make improvements to reduce costs.

D

User Instructions: Select Next to continue.

1 of 20 | Back | Next


Using Improvement Curves
Resources
Glossary
Help
Objectives
At the end of this module, you will be able to:
Identify situations where improvement curve analysis would be appropriate
Identify the steps for using improvement curve analysis
Calculate an objective using improvement curve analysis
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.
OBJECTIVES
User Instructions: Select Next to continue.
2 of 20
Back
Next

Using Improvement Curves

Resources | Glossary | Help

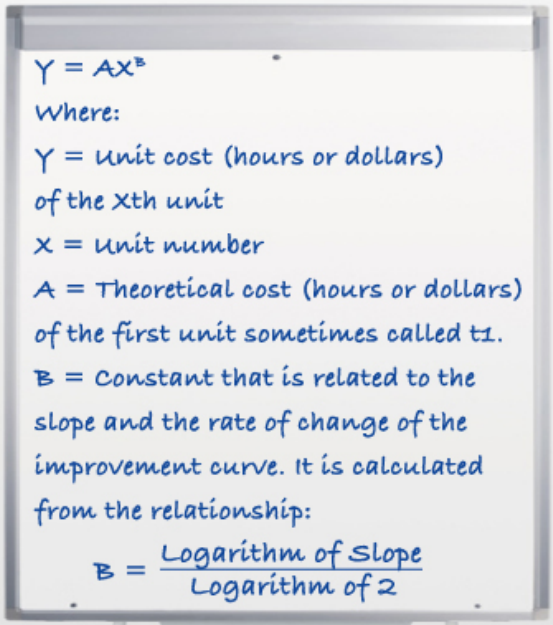
Overview - Basic Improvement Curve Concept

The general concept of the improvement curve is that the resources (labor and/or materials) required to produce each additional unit **decline** as the total number of units produced **increases**.

Two of the most popular improvement curve theories are:

- Unit Improvement Curve -
- Cumulative Average Improvement Curve

Note that the only difference between the curve theories is the word **AVERAGE**. In the unit curve, unit cost is reduced by the same constant percentage. In the cumulative average curve, the cumulative average cost is reduced by the some constant percentage.



D

User Instructions: Select Next to continue.

3 of 20 | Back | Next

Using Improvement Curves

Resources | Glossary | Help

Overview - Identifying Situations for Use

Improvement curves cannot be used as an estimating tool in every situation. Consider using the improvement curve in situations where there is:

- **A high proportion of manual labor** - It is more difficult to reduce the labor input when there is limited labor effort, the labor effort is machine paced, or individual line workers only touch the product for a few seconds.
- **Uninterrupted production** - As more and more units are produced, labor hour requirements decline. If workers, tooling, or other elements are lost during breaks in production, some improvement will also be lost.

User Instructions: Select Next to continue.

4 of 20 | Back | Next

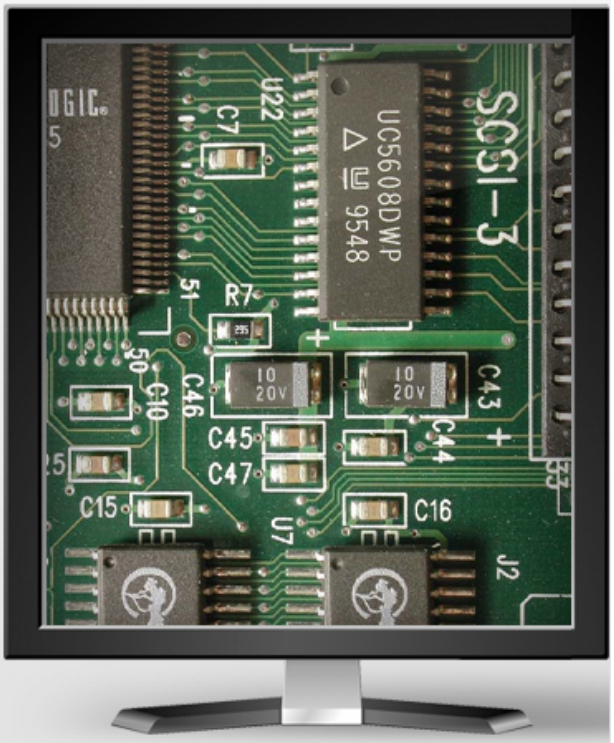
Using Improvement Curves

Resources | Glossary | Help

Overview - Identifying Situations for Use (cont.)

Here are a few more situations in which improvement curve application would be beneficial:

- **Production of complex items** - The more complex the item, the more opportunity there is to improve.
- **No major technological change** - If there are major changes in technology, the benefit of previous improvement may be lost.
- **Continuous pressure to improve** - The management of the firm must exert continuous pressure to improve and be invested in the people and equipment needed to obtain improvement.



User Instructions: Select Next to continue.

5 of 20 | Back | Next

Using Improvement Curves

Resources | Glossary | Help

Overview - Analyzing Improvement Using the Unit Theory

Take a look at the data in the table below. To illustrate the effect of the unit curve, assume that the first unit required 100,000 labor-hours to produce.

If the slope of the curve is 80%, the table demonstrates the labor-hours required to produce units at successively doubled quantities.

The amount of labor-hour reduction between doubled quantities is not constant, but is constantly declining. The **rate** of decline, however, remains constant (20%).

Units Produced	Labor Hours/Unit (at doubled quantities)	Difference in Labor Hours/Unit (at doubled quantities)	Rate of Improvement (%)	Slope of Curve(%)
1	100,000			
2	80,000	20,000	20	80
4	64,000	16,000	20	80
8	51,200	12,800	20	80
16	40,960	10,240	20	80
32	32,768	8,192	20	80

User Instructions: Select Next to continue.

6 of 19 Back Next

Using Improvement Curves

Resources | Glossary | Help

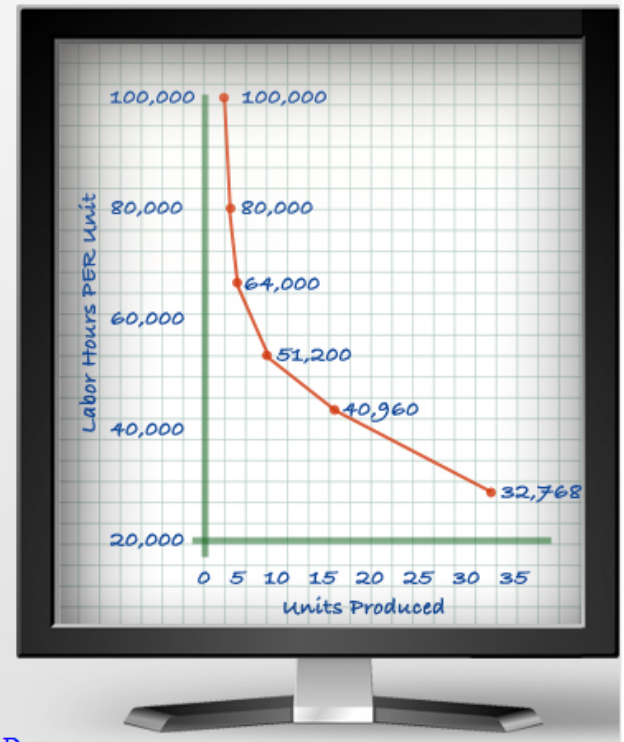
Overview - Graphing the Data

Graphing the unit improvement curve demonstrates the relationship between the total units produced and unit cost.

A labor-hour graph of this data drawn on ordinary graph paper becomes a curve as shown in the graph to the right.

The graph is a curve because the number of labor-hour reduction between doubled quantities is constantly declining and an increasing number of units are required to double the quantity produced.

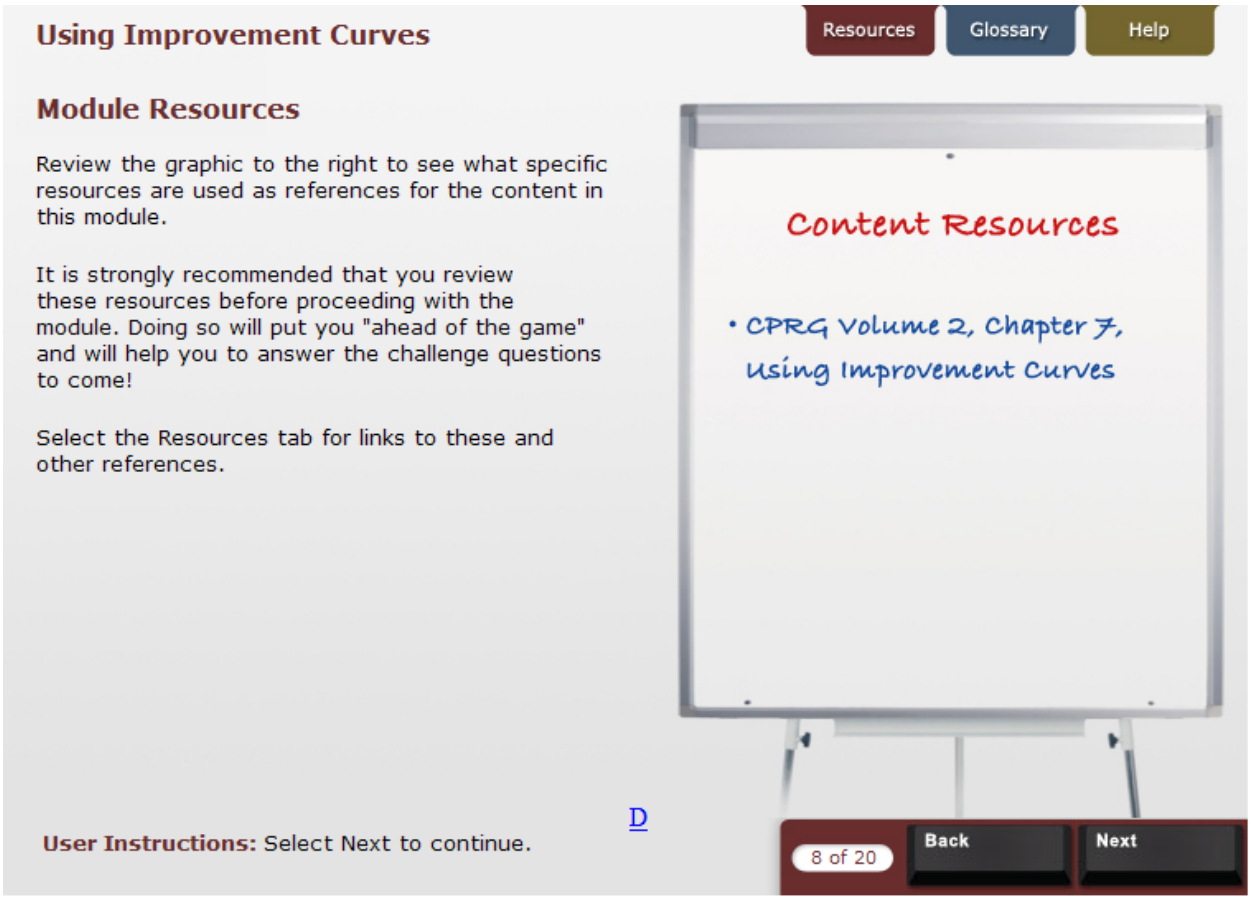
Note that most of the improvement takes place during the early units of production.

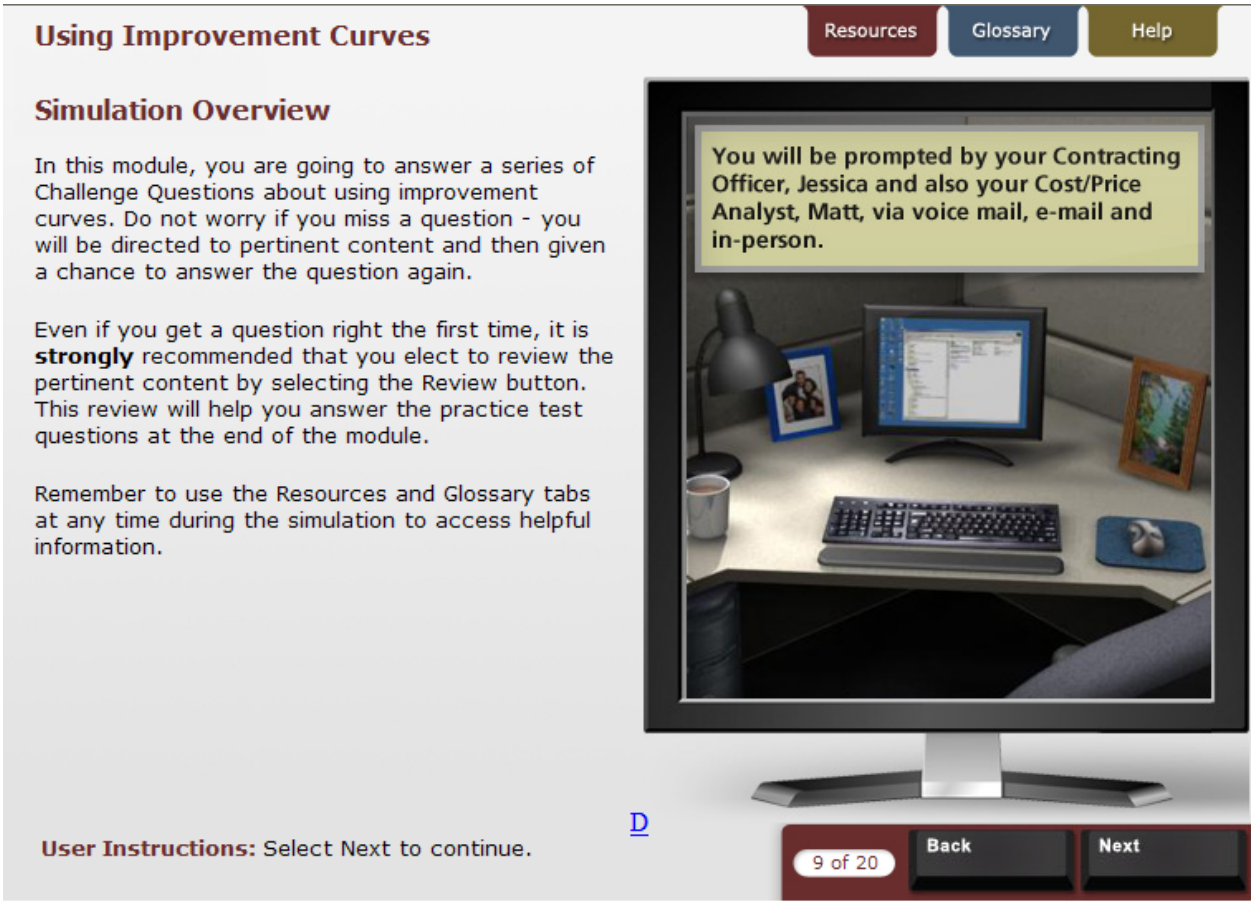


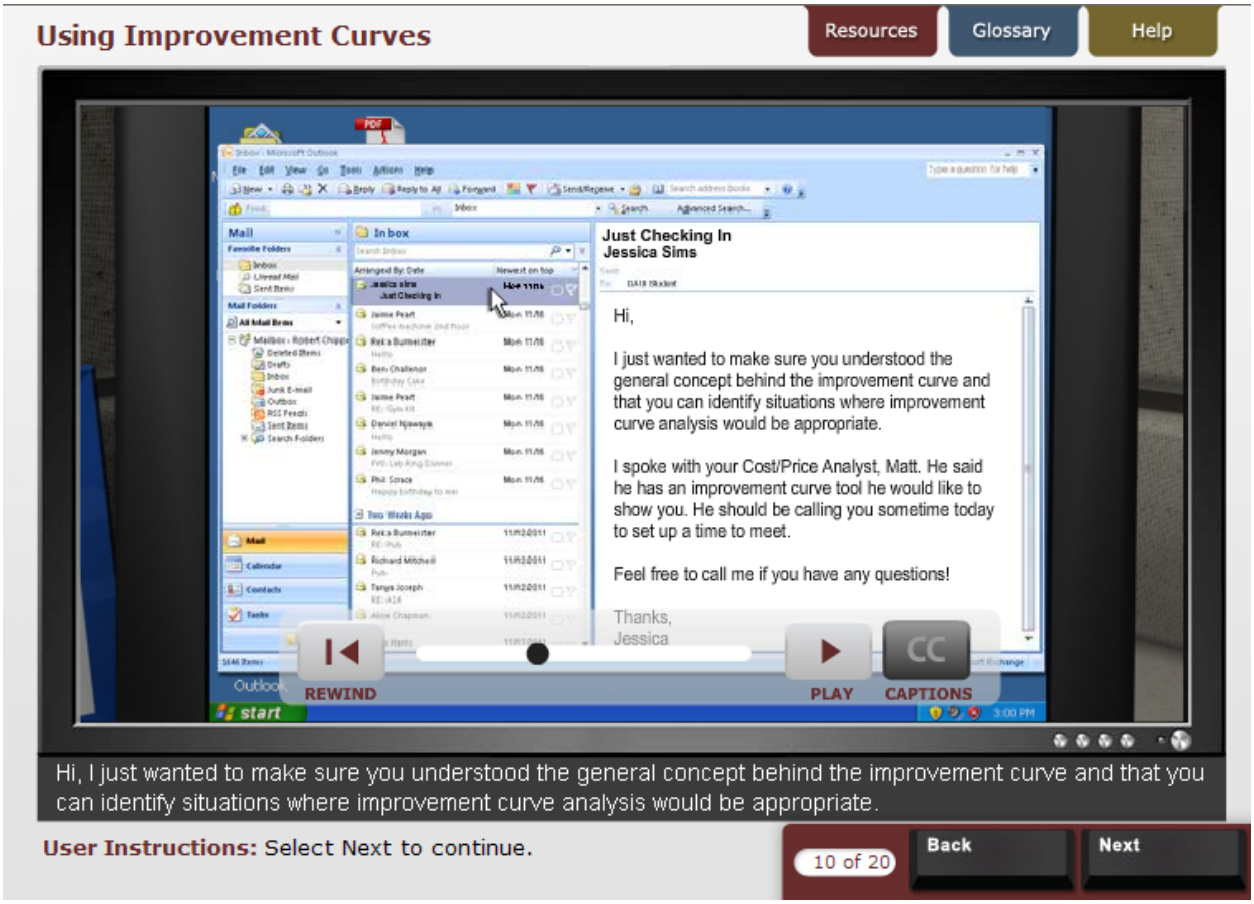
D

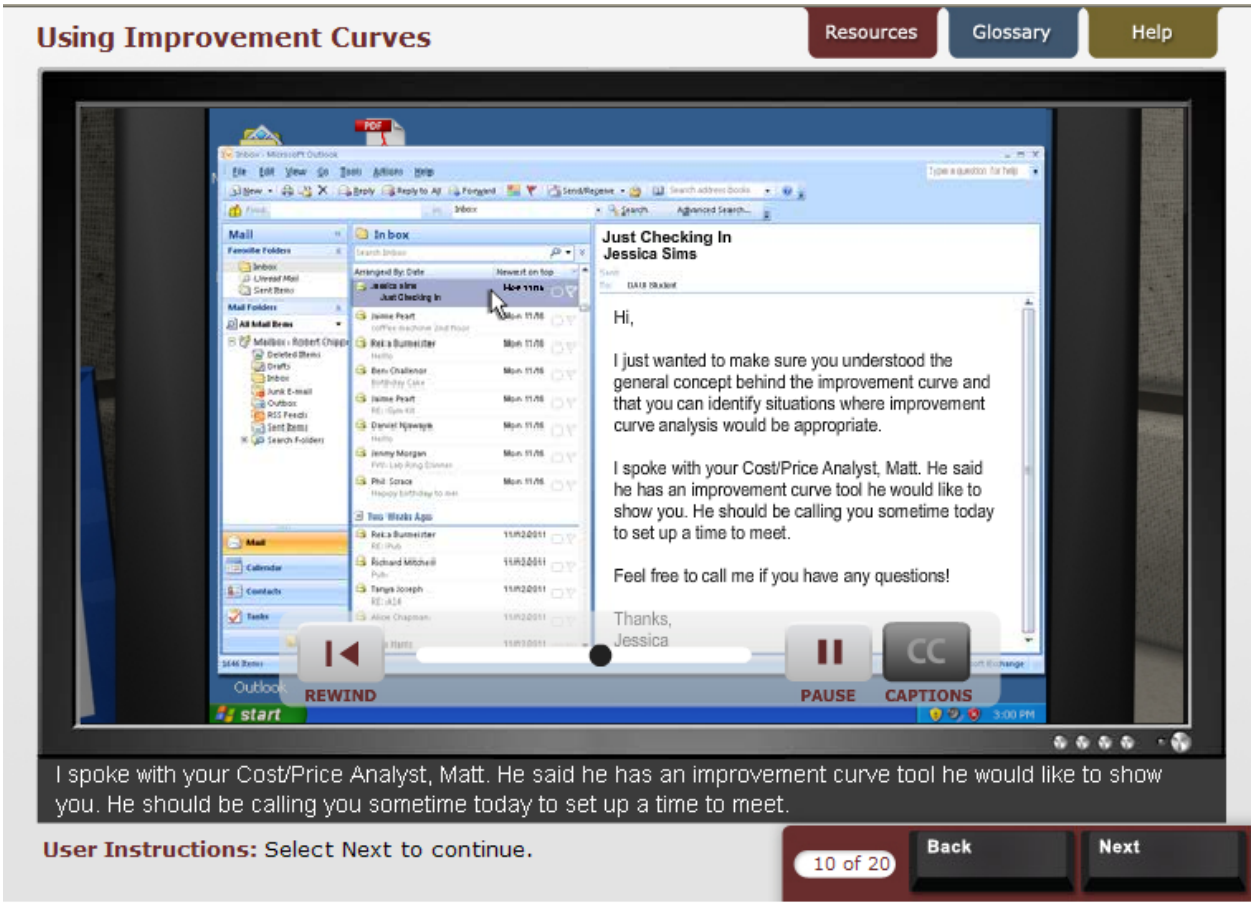
User Instructions: Select Next to continue.

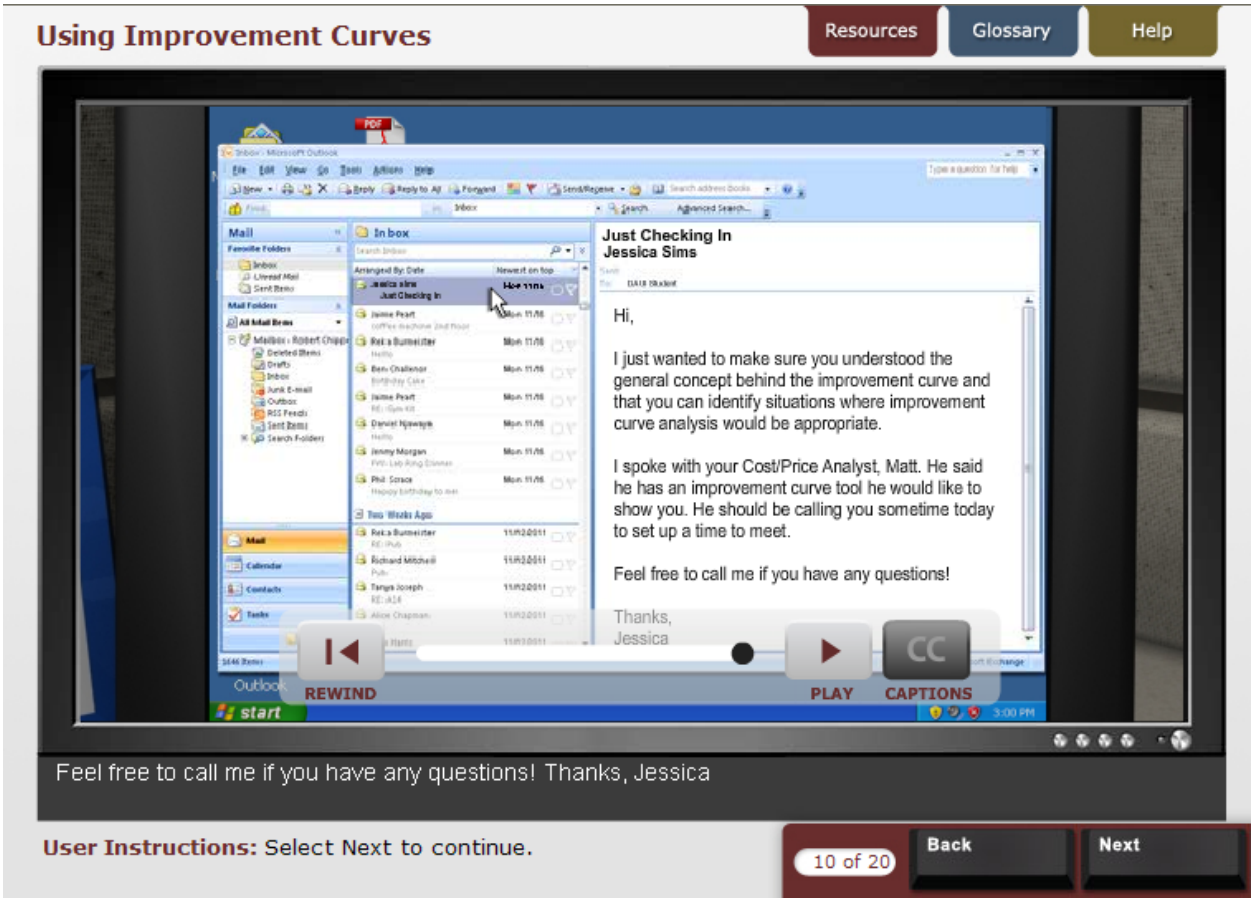
7 of 20 | Back | Next

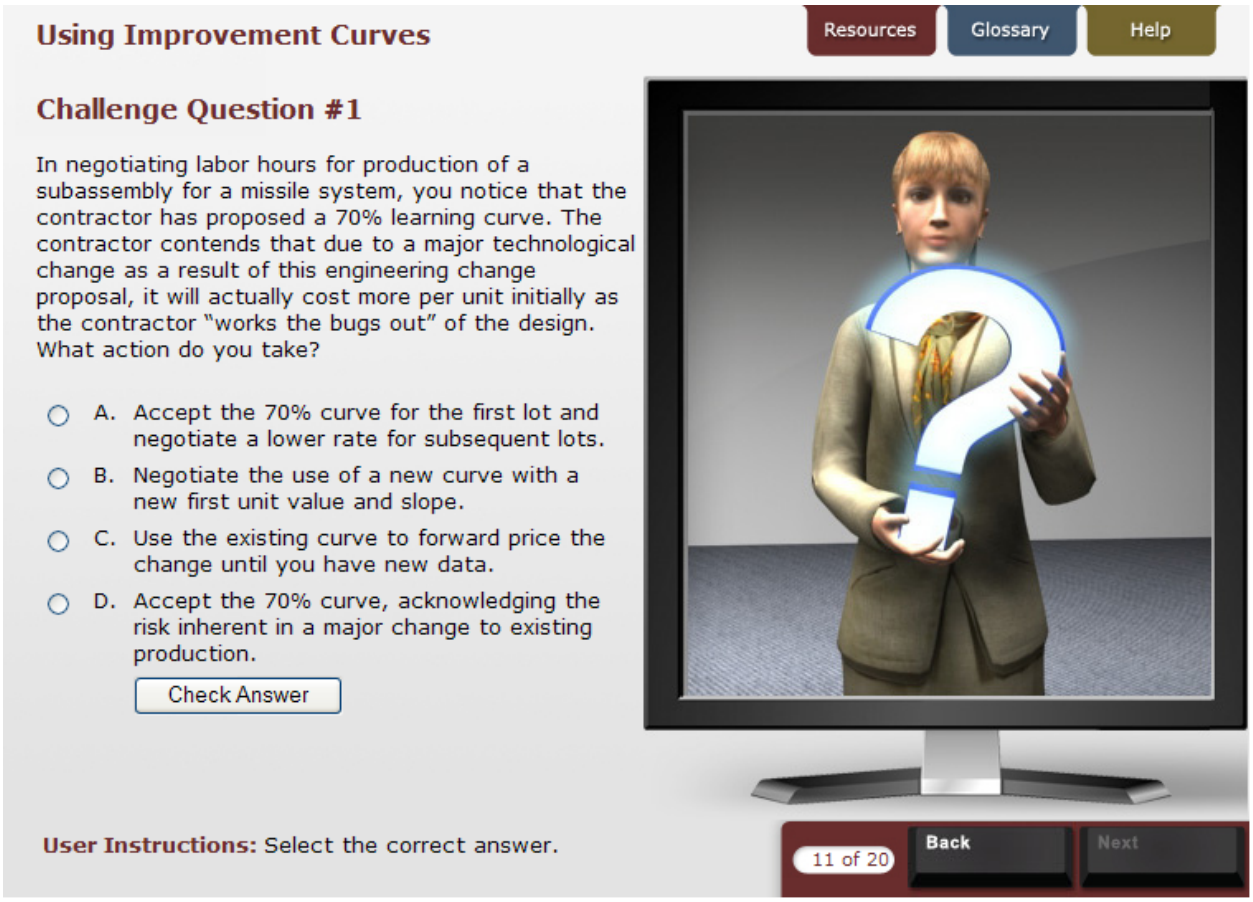

Using Improvement Curves
Resources
Glossary
Help
Module Resources
Review the graphic to the right to see what specific resources are used as references for the content in this module.
It is strongly recommended that you review these resources before proceeding with the module. Doing so will put you "ahead 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 7, Using Improvement Curves
D
User Instructions: Select Next to continue.
8 of 20
Back
Next

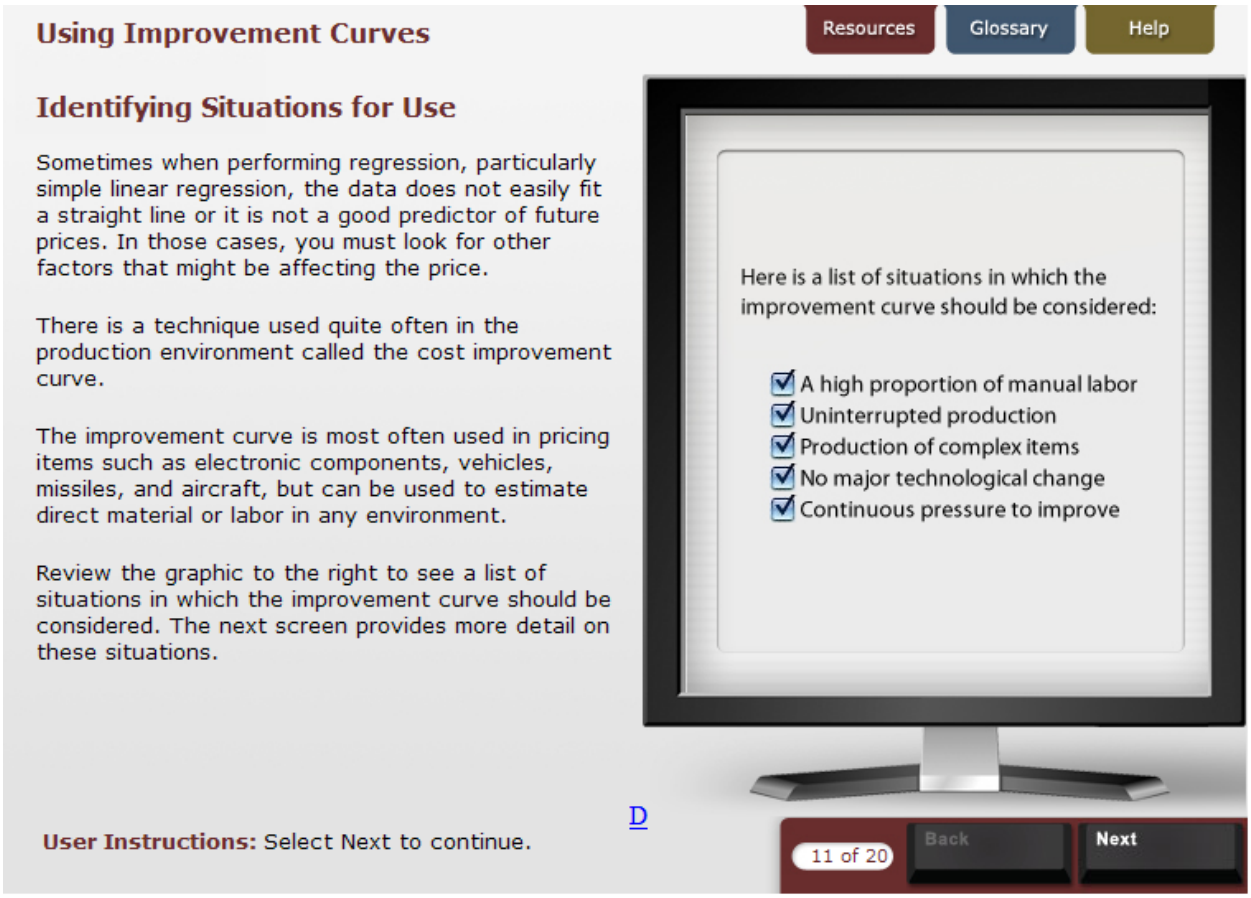

Using Improvement Curves
Resources
Glossary
Help
Simulation Overview
In this module, you are going to answer a series of Challenge Questions about using improvement curves. Do not worry if you miss a question - you will be directed to pertinent content and then given a chance to answer the question again.
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.
You will be prompted by your Contracting Officer, Jessica and also your Cost/Price Analyst, Matt, via voice mail, e-mail and in-person.
D
User Instructions: Select Next to continue.
9 of 20
Back
Next

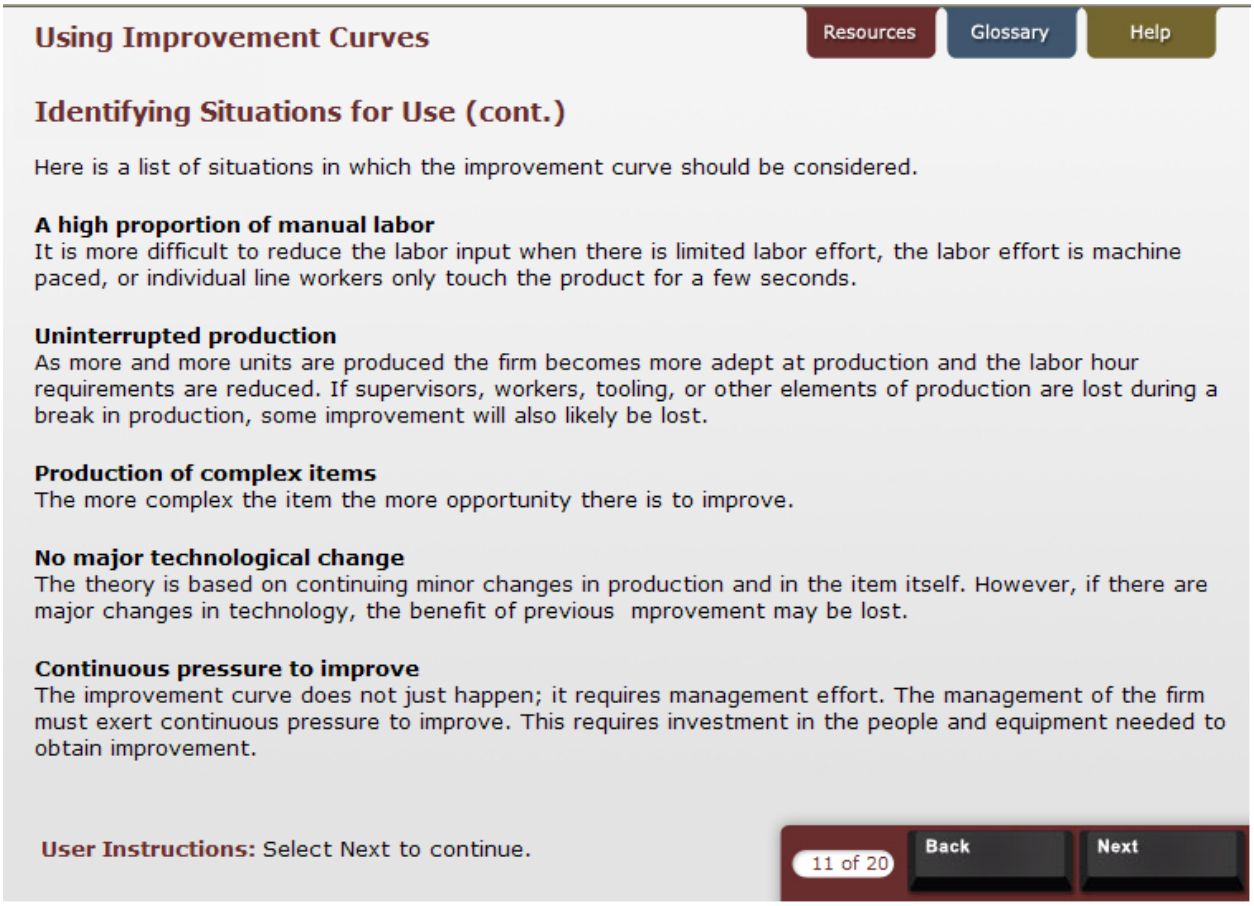

Using Improvement Curves
Resources
Glossary
Help
Just Checking In
Jessica Sims
Hi,
I just wanted to make sure you understood the general concept behind the improvement curve and that you can identify situations where improvement curve analysis would be appropriate.
I spoke with your Cost/Price Analyst, Matt. He said he has an improvement curve tool he would like to show you. He should be calling you sometime today to set up a time to meet.
Feel free to call me if you have any questions!
Thanks,
Jessica
REWIND
PLAY
CAPTIONS
Hi, I just wanted to make sure you understood the general concept behind the improvement curve and that you can identify situations where improvement curve analysis would be appropriate.
User Instructions: Select Next to continue.
10 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Just Checking In
Jessica Sims
Hi,
I just wanted to make sure you understood the general concept behind the improvement curve and that you can identify situations where improvement curve analysis would be appropriate.
I spoke with your Cost/Price Analyst, Matt. He said he has an improvement curve tool he would like to show you. He should be calling you sometime today to set up a time to meet.
Feel free to call me if you have any questions!
Thanks,
Jessica
REWIND
PAUSE
CAPTIONS
I spoke with your Cost/Price Analyst, Matt. He said he has an improvement curve tool he would like to show you. He should be calling you sometime today to set up a time to meet.
User Instructions: Select Next to continue.
10 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Just Checking In
Jessica Sims
Hi,
I just wanted to make sure you understood the general concept behind the improvement curve and that you can identify situations where improvement curve analysis would be appropriate.
I spoke with your Cost/Price Analyst, Matt. He said he has an improvement curve tool he would like to show you. He should be calling you sometime today to set up a time to meet.
Feel free to call me if you have any questions!
Thanks,
Jessica
REWIND
PLAY
CAPTIONS
Feel free to call me if you have any questions! Thanks, Jessica
User Instructions: Select Next to continue.
10 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Challenge Question #1
In negotiating labor hours for production of a subassembly for a missile system, you notice that the contractor has proposed a 70% learning curve. The contractor contends that due to a major technological change as a result of this engineering change proposal, it will actually cost more per unit initially as the contractor "works the bugs out" of the design. What action do you take?
A. Accept the 70% curve for the first lot and negotiate a lower rate for subsequent lots.
B. Negotiate the use of a new curve with a new first unit value and slope.
C. Use the existing curve to forward price the change until you have new data.
D. Accept the 70% curve, acknowledging the risk inherent in a major change to existing production.
Check Answer
User Instructions: Select the correct answer.
11 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Identifying Situations for Use
Sometimes when performing regression, particularly simple linear regression, the data does not easily fit a straight line or it is not a good predictor of future prices. In those cases, you must look for other factors that might be affecting the price.
There is a technique used quite often in the production environment called the cost improvement curve.
The improvement curve is most often used in pricing items such as electronic components, vehicles, missiles, and aircraft, but can be used to estimate direct material or labor in any environment.
Review the graphic to the right to see a list of situations in which the improvement curve should be considered. The next screen provides more detail on these situations.
Here is a list of situations in which the improvement curve should be considered:
A high proportion of manual labor
Uninterrupted production
Production of complex items
No major technological change
Continuous pressure to improve
D
User Instructions: Select Next to continue.
11 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Identifying Situations for Use (cont.)
Here is a list of situations in which the improvement curve should be considered.
A high proportion of manual labor
It is more difficult to reduce the labor input when there is limited labor effort, the labor effort is machine paced, or individual line workers only touch the product for a few seconds.
Uninterrupted production
As more and more units are produced the firm becomes more adept at production and the labor hour requirements are reduced. If supervisors, workers, tooling, or other elements of production are lost during a break in production, some improvement will also likely be lost.
Production of complex items
The more complex the item the more opportunity there is to improve.
No major technological change
The theory is based on continuing minor changes in production and in the item itself. However, if there are major changes in technology, the benefit of previous mprovement may be lost.
Continuous pressure to improve
The improvement curve does not just happen; it requires management effort. The management of the firm must exert continuous pressure to improve. This requires investment in the people and equipment needed to obtain improvement.
User Instructions: Select Next to continue.
11 of 20
Back
Next

Using Improvement Curves

Resources | Glossary | Help

Factors that Support Improvement

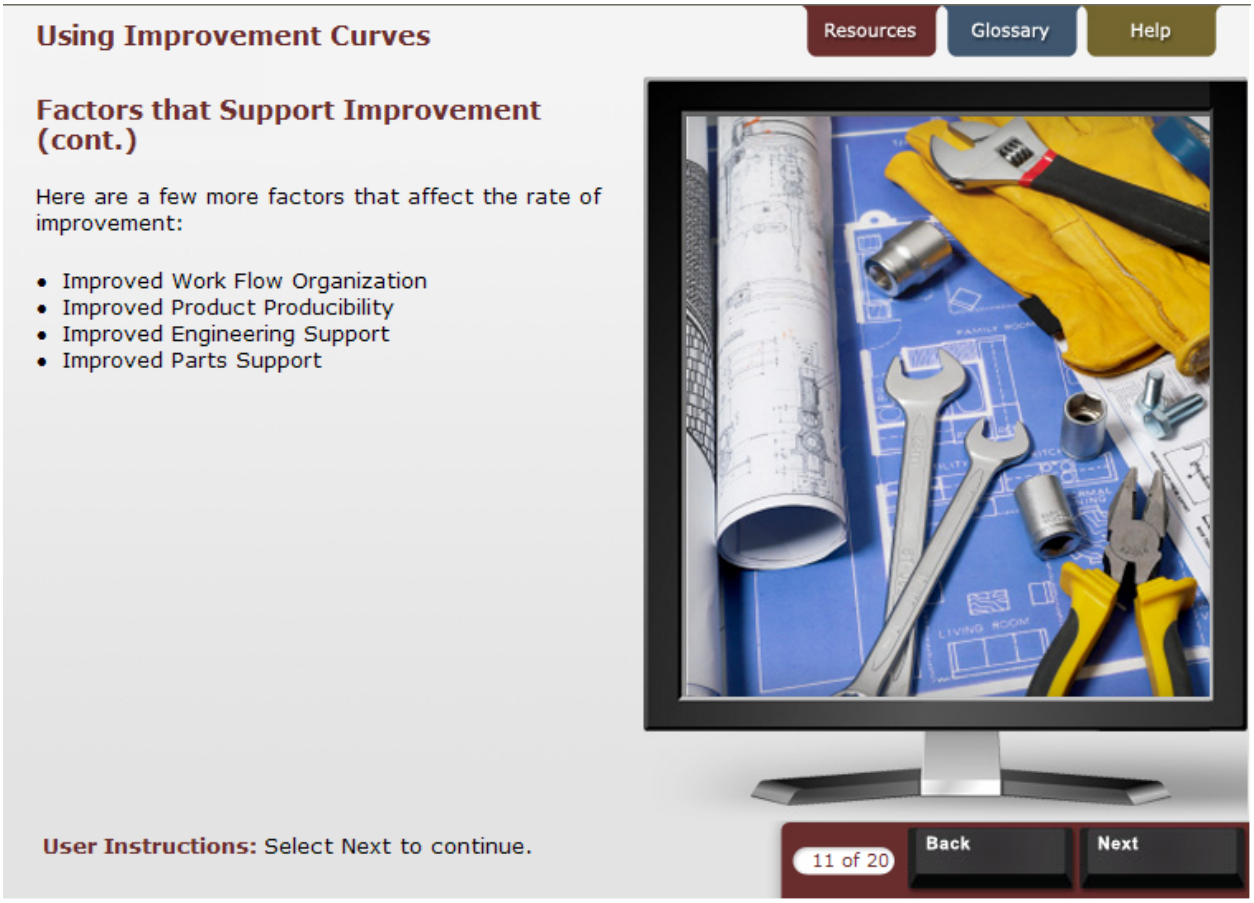
The use of improvement curve theory can be useful when it makes sense, but would not be used in every pricing situation. In fact, the improvement curve theory was not used on the BBOMS contract.

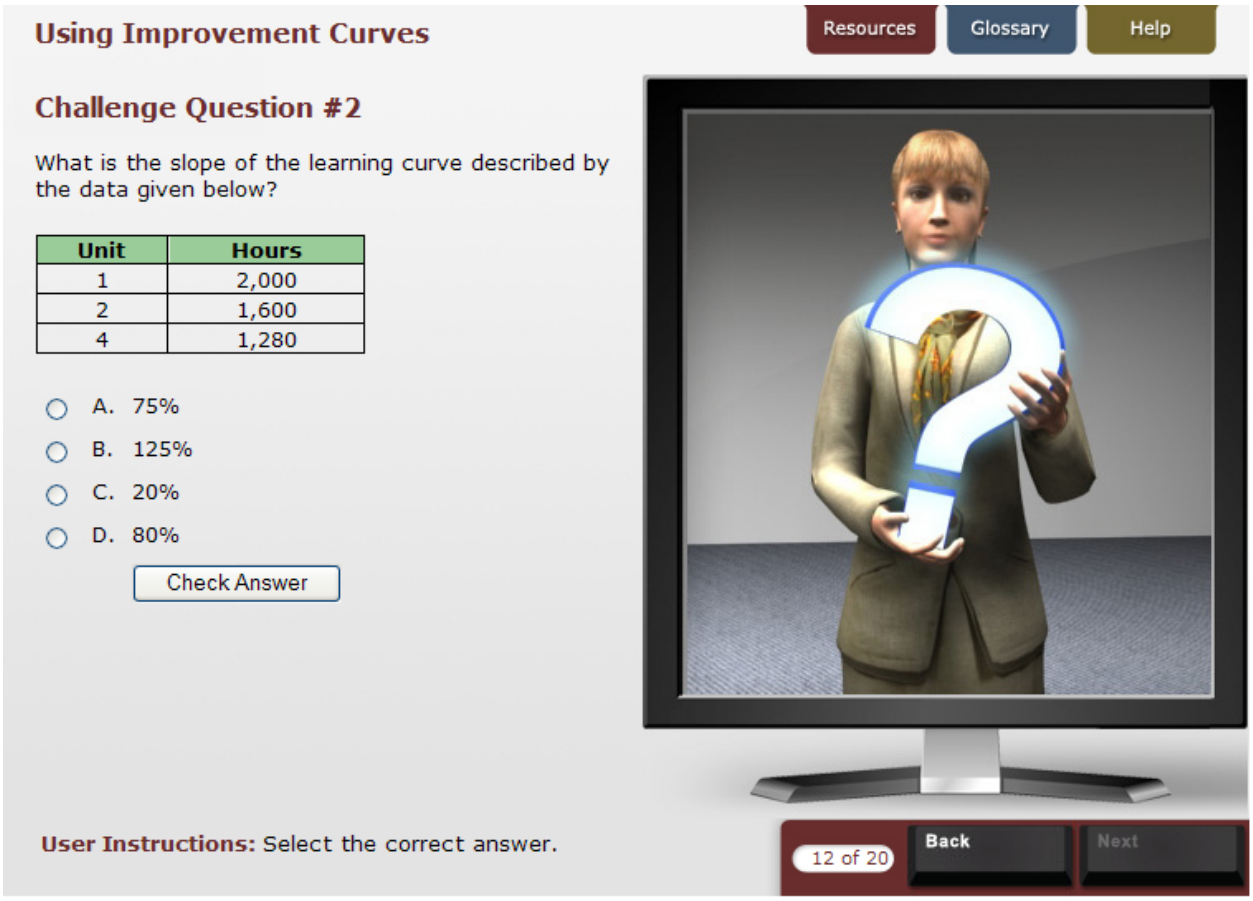
As you examine situations that appear to have potential for improvement curve application, consider management emphasis on the following factors affecting the rate of improvement:

- Job Familiarization By Workers
- Improved Production Procedures
- Improved Tooling and Tool Coordination

User Instructions: Select Next to continue.

11 of 20 | Back | Next


Using Improvement Curves
Resources
Glossary
Help
Factors that Support Improvement (cont.)
Here are a few more factors that affect the rate of improvement:
• Improved Work Flow Organization
• Improved Product Producibility
• Improved Engineering Support
• Improved Parts Support
User Instructions: Select Next to continue.
11 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Challenge Question #2
What is the slope of the learning curve described by the data given below?
Unit
Hours
1
2,000
2
1,600
4
1,280
A. 75%
B. 125%
C. 20%
D. 80%
Check Answer
User Instructions: Select the correct answer.
12 of 20
Back
Next

Using Improvement Curves

Resources | Glossary | Help

Calculating Theoretical Cost

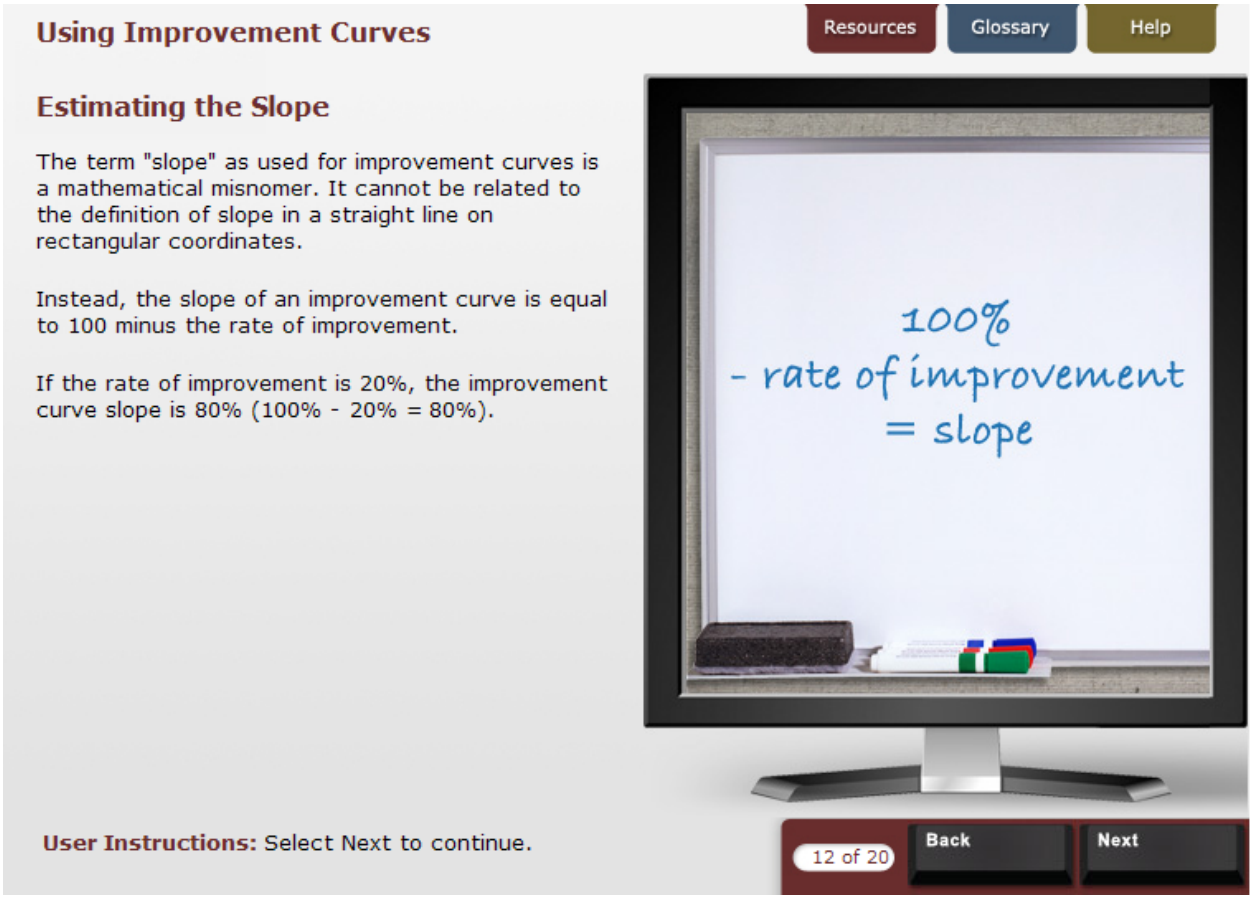
When we discuss improvement curves, we normally describe them in terms of the **theoretical value** for Unit #1 and the **slope of the curve**.

The value of Unit #1 is referred to as a theoretical value (T_1), because in most cases you will not know the actual cost of Unit #1. Instead, T_1 is the value indicated by the line-of-best-fit.

D

User Instructions: Select Next to continue.

12 of 20 | Back | Next


Using Improvement Curves
Resources
Glossary
Help
Estimating the Slope
The term "slope" as used for improvement curves is a mathematical misnomer. It cannot be related to the definition of slope in a straight line on rectangular coordinates.
Instead, the slope of an improvement curve is equal to 100 minus the rate of improvement.
If the rate of improvement is 20%, the improvement curve slope is 80% (100% - 20% = 80%).
100%
- rate of improvement
= slope
User Instructions: Select Next to continue.
12 of 20
Back
Next

Using Improvement Curves

Resources | Glossary | Help

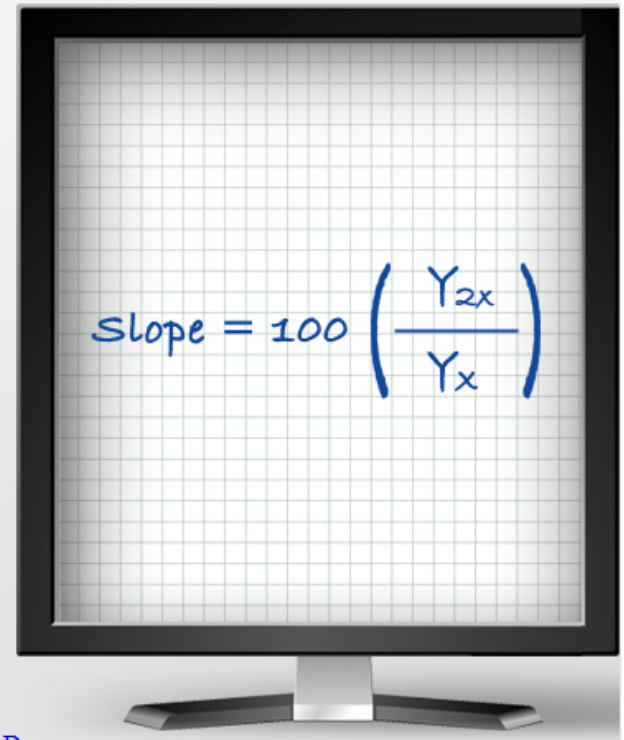
Calculating the Slope

You can calculate the slope of a curve, by dividing the unit cost (Y_X) at some unit (X) into the unit cost (Y_{2X}) at twice the quantity (2X) and multiplying the resulting ratio by 100.

For example, if the number of hours to make Unit #5 is 70 and the number of hours to make Unit #10 is 50, calculate the slope like this:

50/70 = 0.714 * 100

The slope of the improvement curve is 71.4%.



D

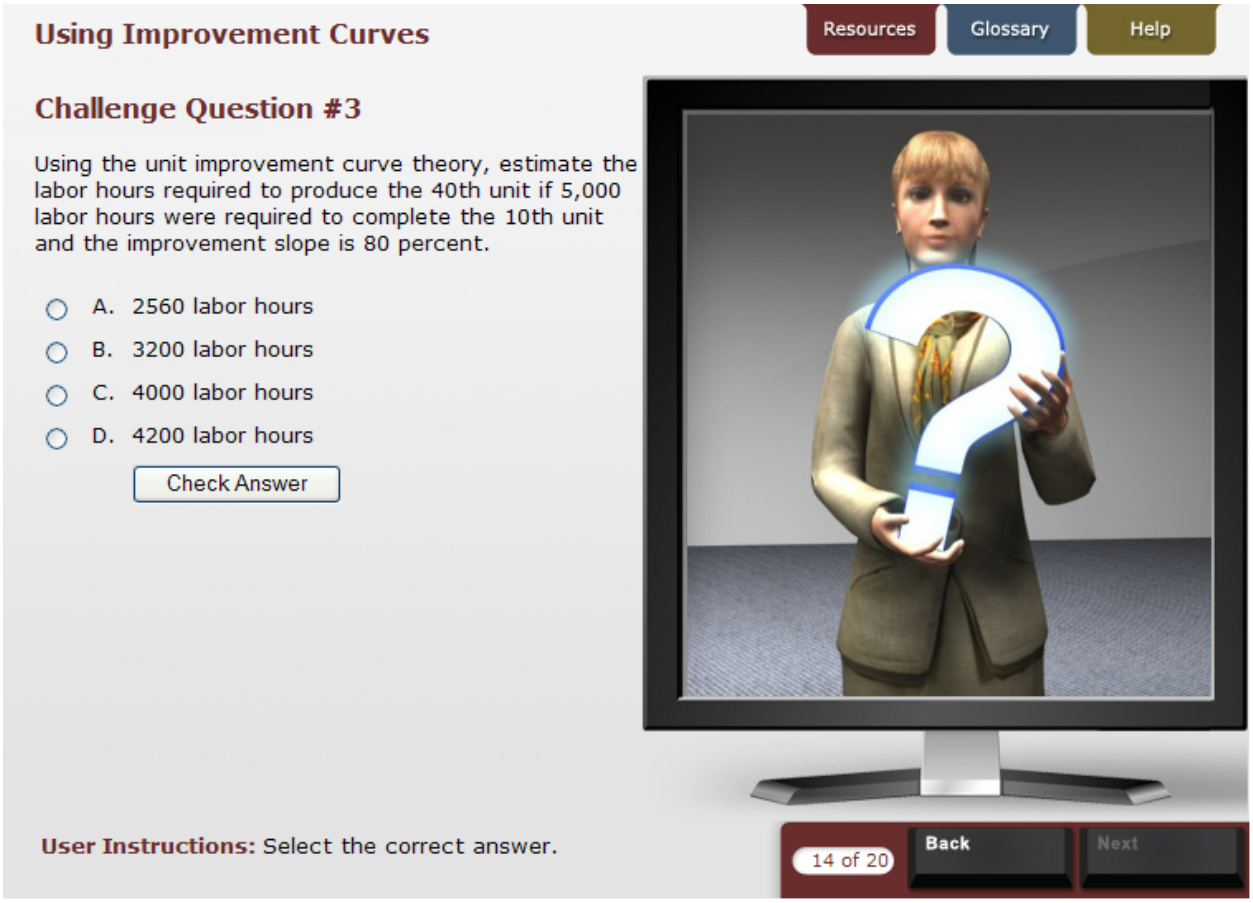
User Instructions: Select Next to continue.

12 of 20 | Back | Next


Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CAPTIONS
Hi, this is Matt, your Cost/Price Analyst. I was hoping that you had some time today to meet with me so I can show you how to use the improvement curve spreadsheet tool.
User Instructions: Select Next to continue.
13 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CAPTIONS
How about meeting me in the conference room at 1400 hours?
User Instructions: Select Next to continue.
13 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CAPTIONS
Until then, why don't you review how to use the improvement curve theory to estimate future unit costs. Thanks!
User Instructions: Select Next to continue.
13 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Challenge Question #3
Using the unit improvement curve theory, estimate the labor hours required to produce the 40th unit if 5,000 labor hours were required to complete the 10th unit and the improvement slope is 80 percent.
A. 2560 labor hours
B. 3200 labor hours
C. 4000 labor hours
D. 4200 labor hours
Check Answer
User Instructions: Select the correct answer.
14 of 20
Back
Next

Using Improvement Curves

Resources | Glossary | Help

Estimating the Cost of Future Units

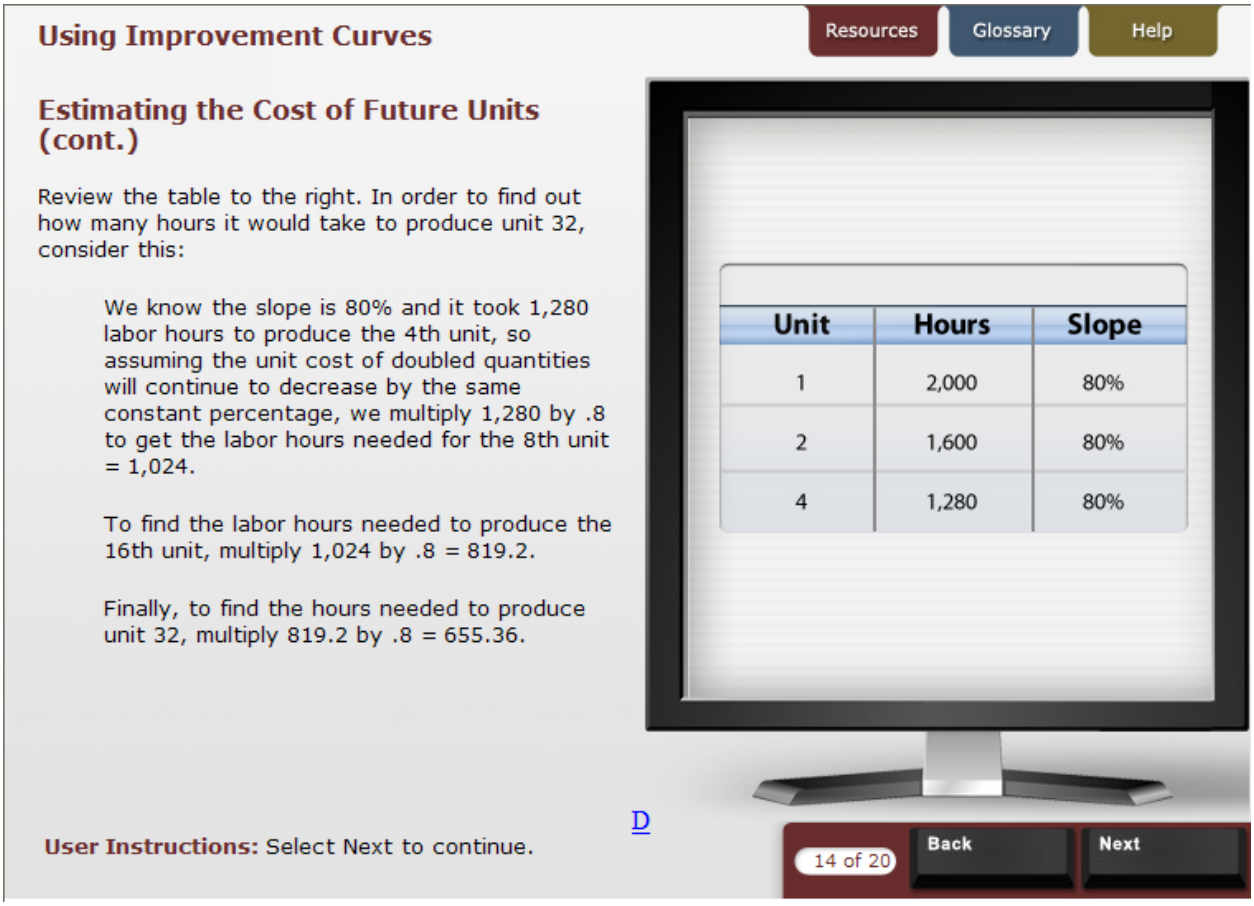
The primary purpose for estimating an improvement curve is to predict the cost of future production.

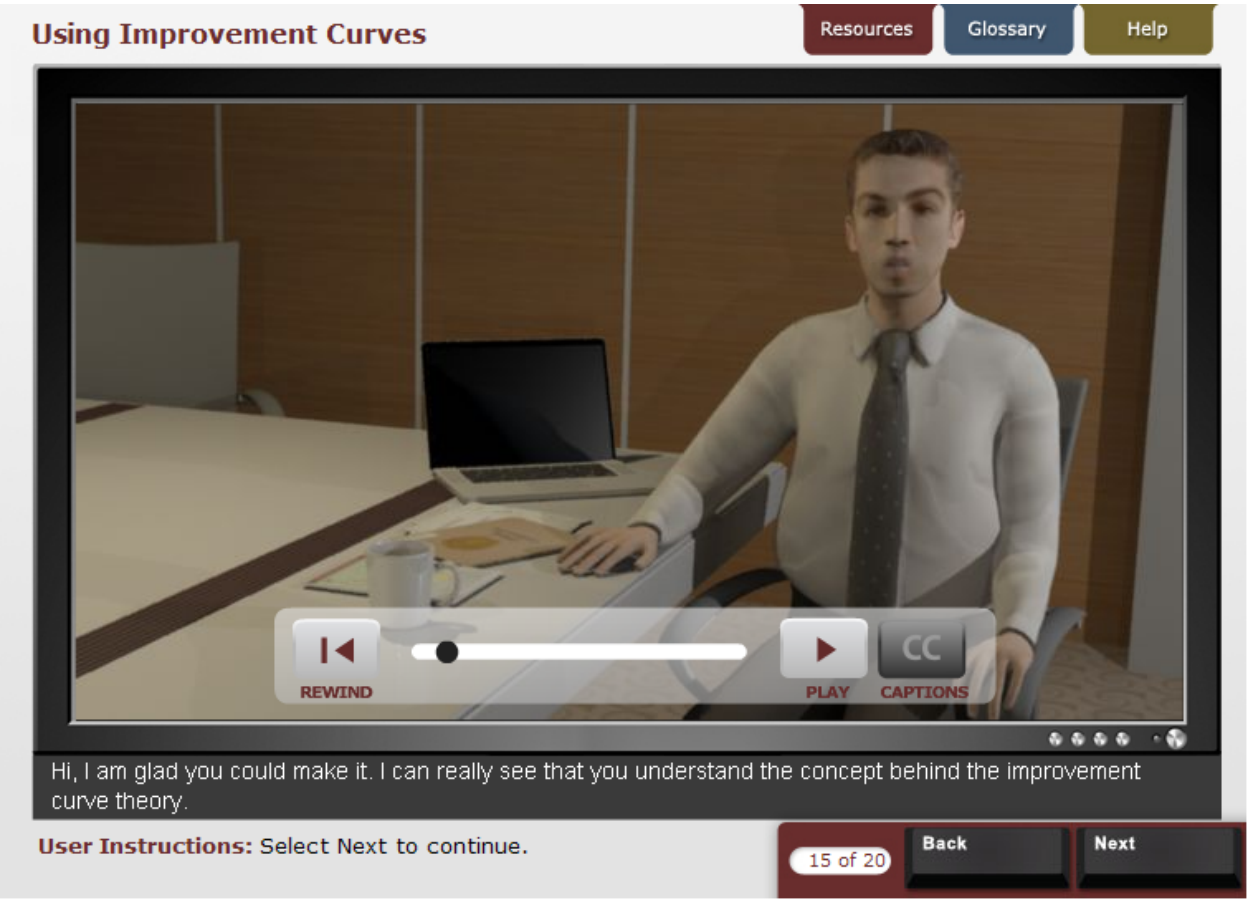
The prediction is based on the **assumption** that the past is a good predictor of the future.

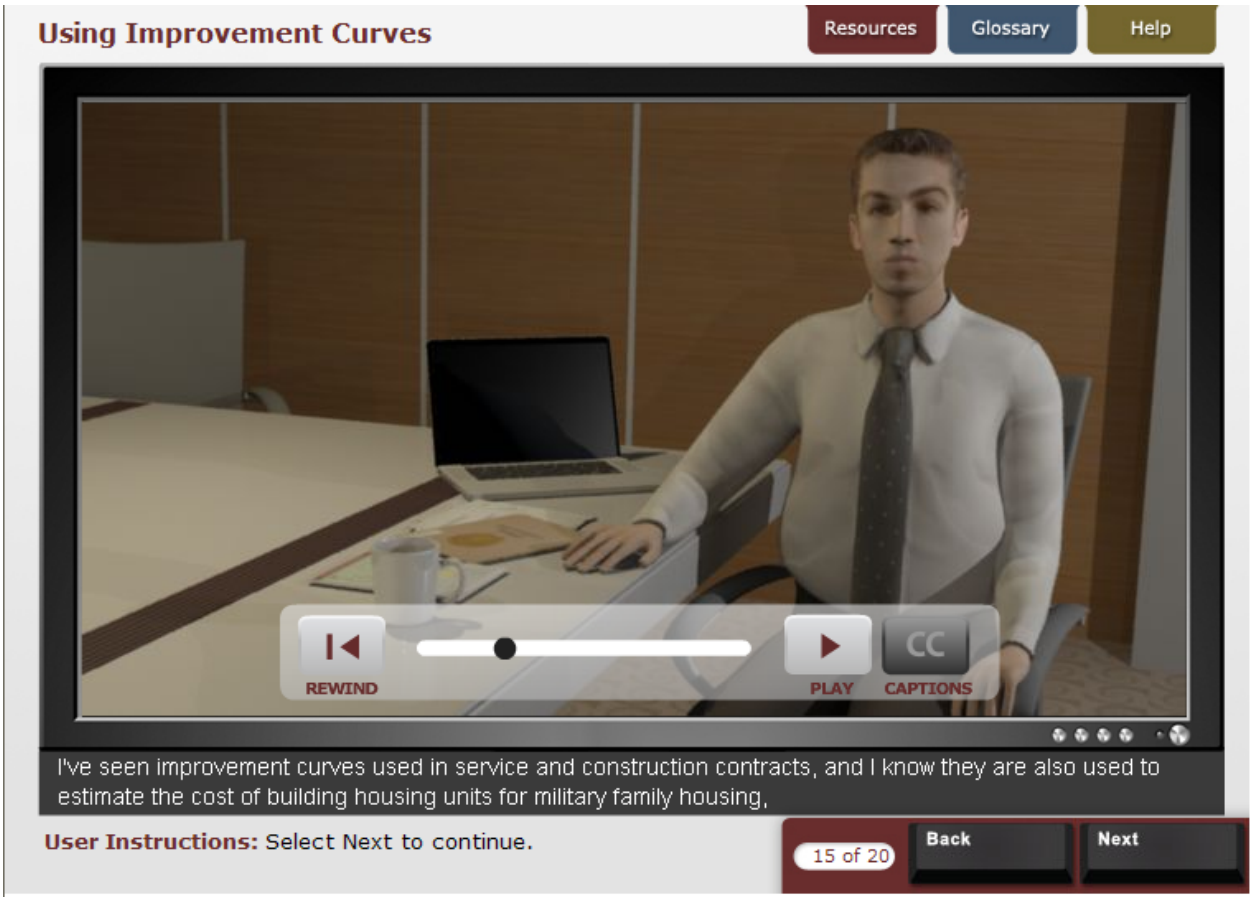
In terms of the unit improvement curve theory, this assumption means that the unit cost of doubled quantities will continue to decrease by the same constant percentage.

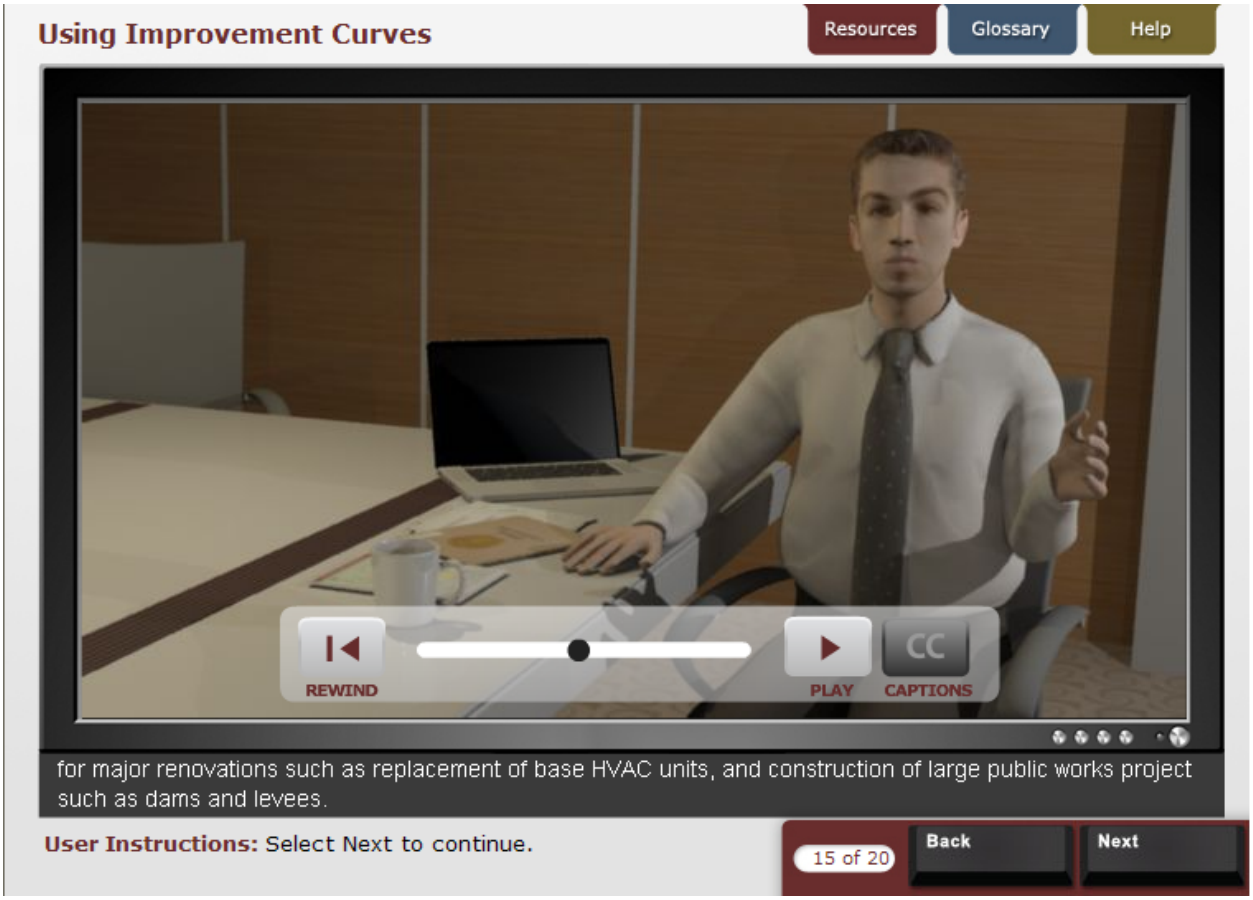
User Instructions: Select Next to continue.

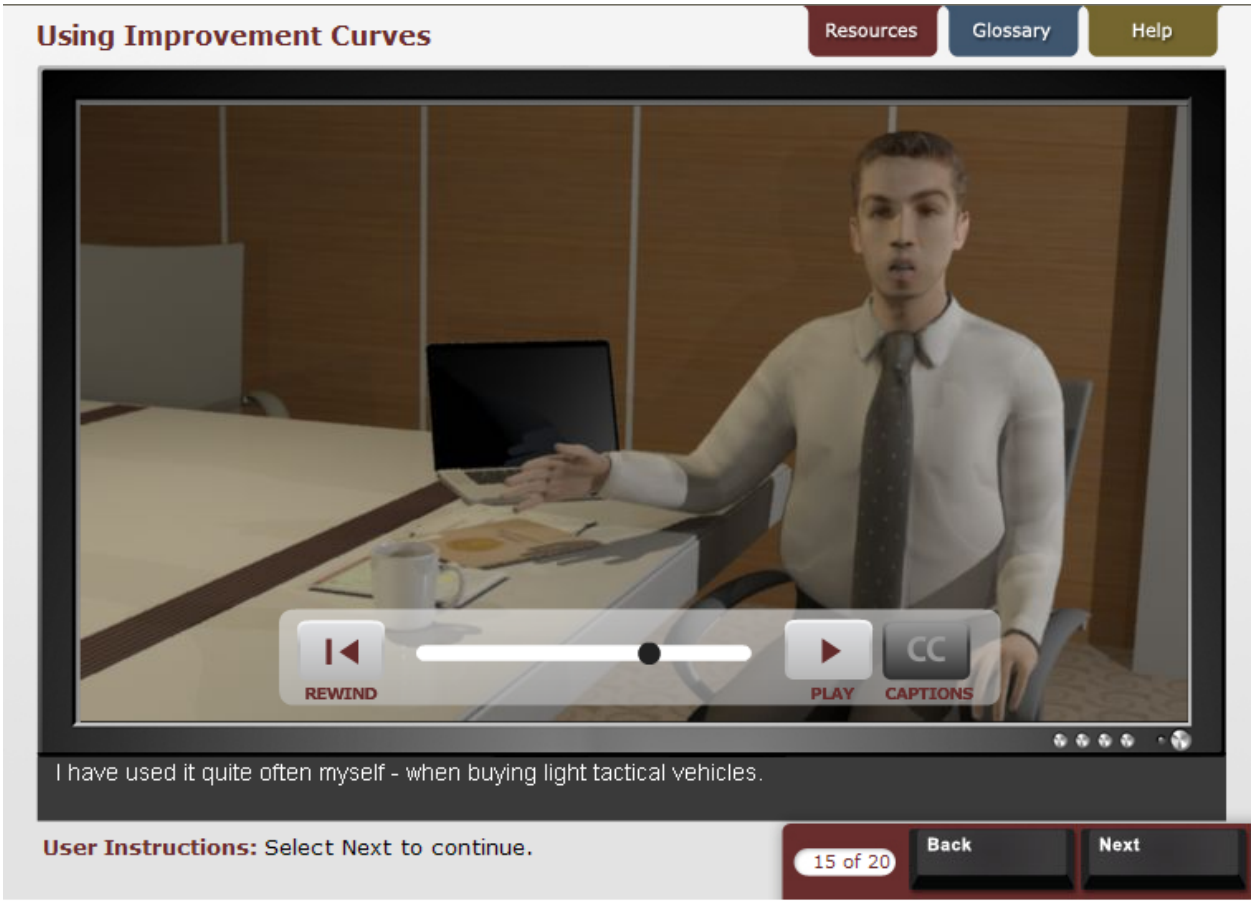
14 of 20 | Back | Next

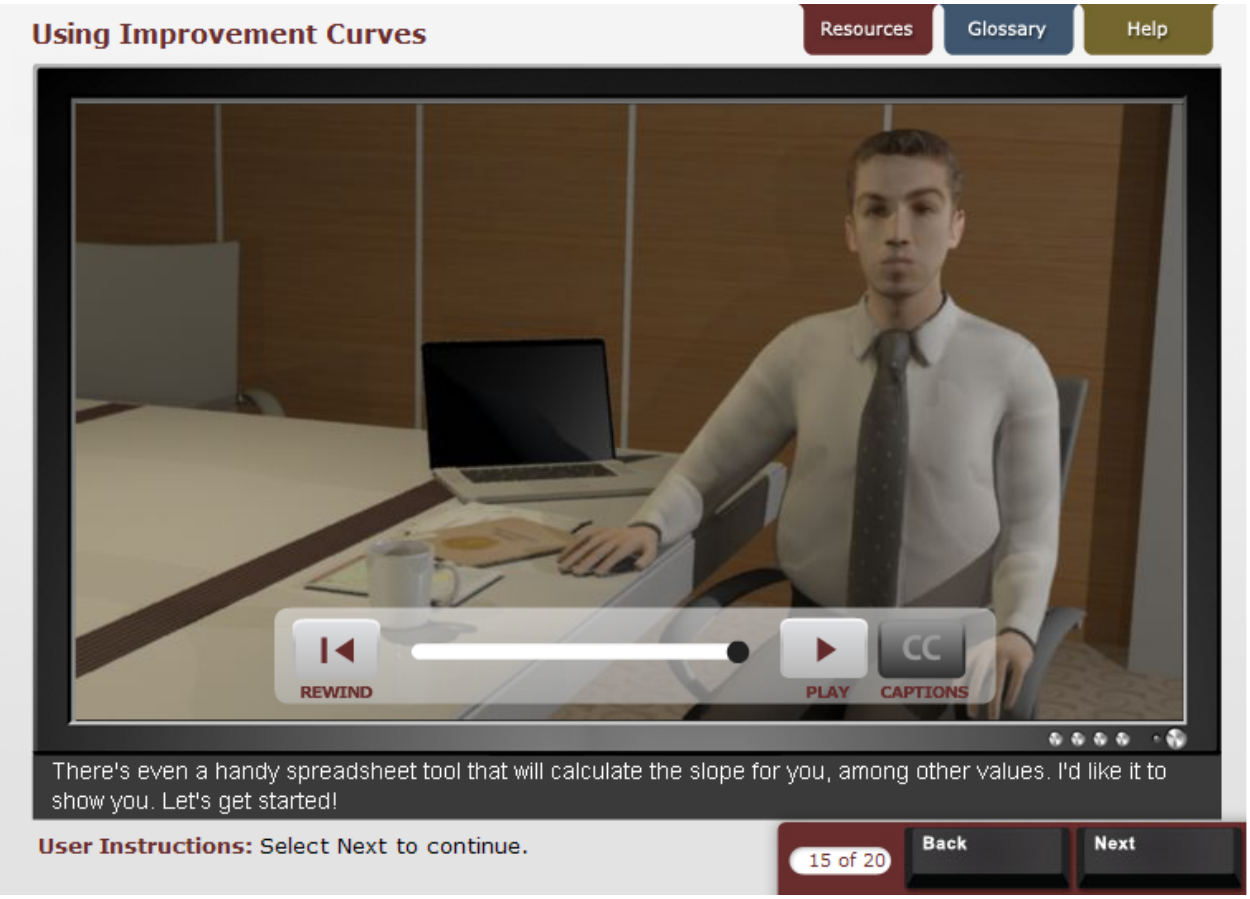

Using Improvement Curves
Resources
Glossary
Help
Estimating the Cost of Future Units (cont.)
Review the table to the right. In order to find out how many hours it would take to produce unit 32, consider this:
We know the slope is 80% and it took 1,280 labor hours to produce the 4th unit, so assuming the unit cost of doubled quantities will continue to decrease by the same constant percentage, we multiply 1,280 by .8 to get the labor hours needed for the 8th unit = 1,024.
To find the labor hours needed to produce the 16th unit, multiply 1,024 by .8 = 819.2.
Finally, to find the hours needed to produce unit 32, multiply 819.2 by .8 = 655.36.
Unit Hours Slope
1 2,000 80%
2 1,600 80%
4 1,280 80%
D
User Instructions: Select Next to continue.
14 of 20
Back
Next

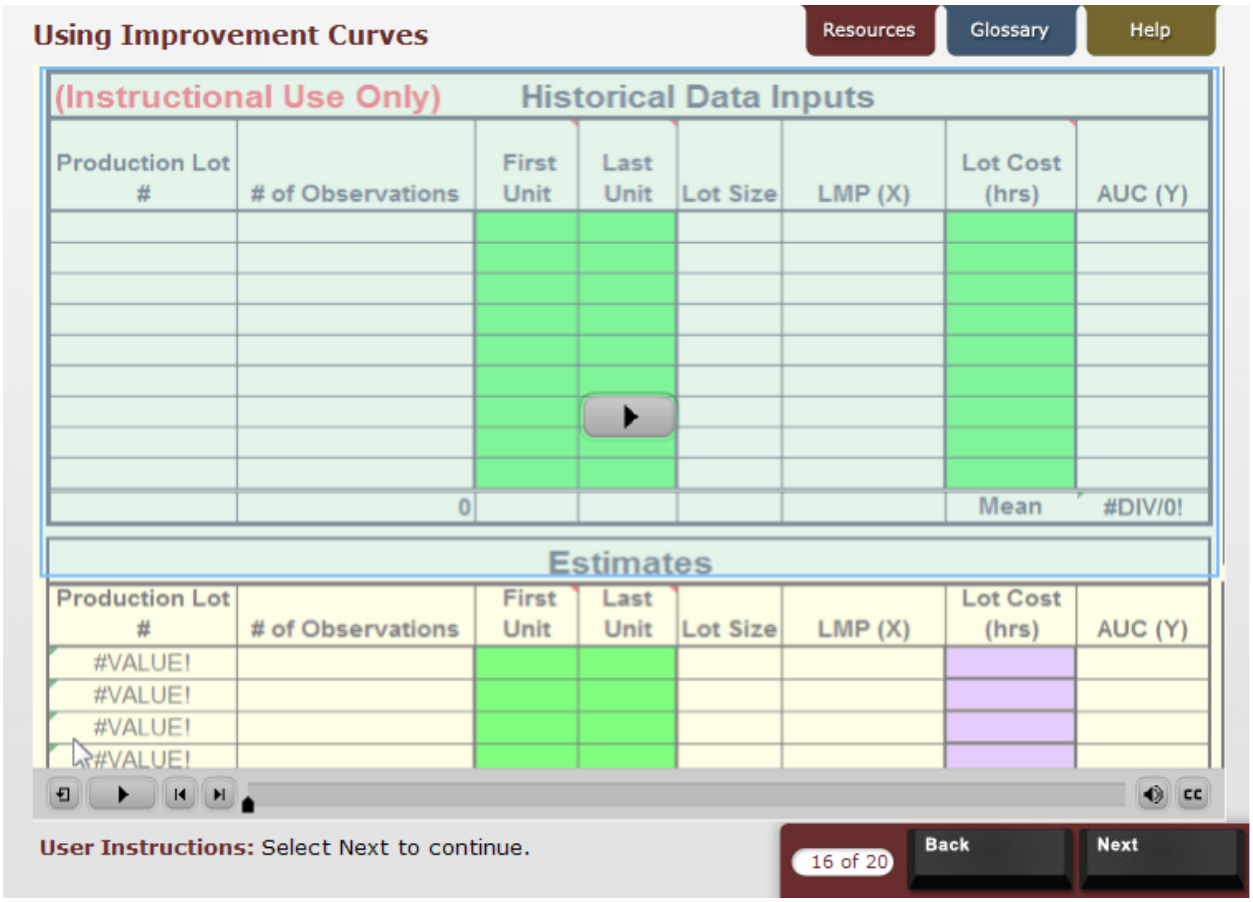

Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CC
CAPTIONS
Hi, I am glad you could make it. I can really see that you understand the concept behind the improvement curve theory.
User Instructions: Select Next to continue.
15 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CC
CAPTIONS
I've seen improvement curves used in service and construction contracts, and I know they are also used to estimate the cost of building housing units for military family housing.
User Instructions: Select Next to continue.
15 of 20
Back
Next

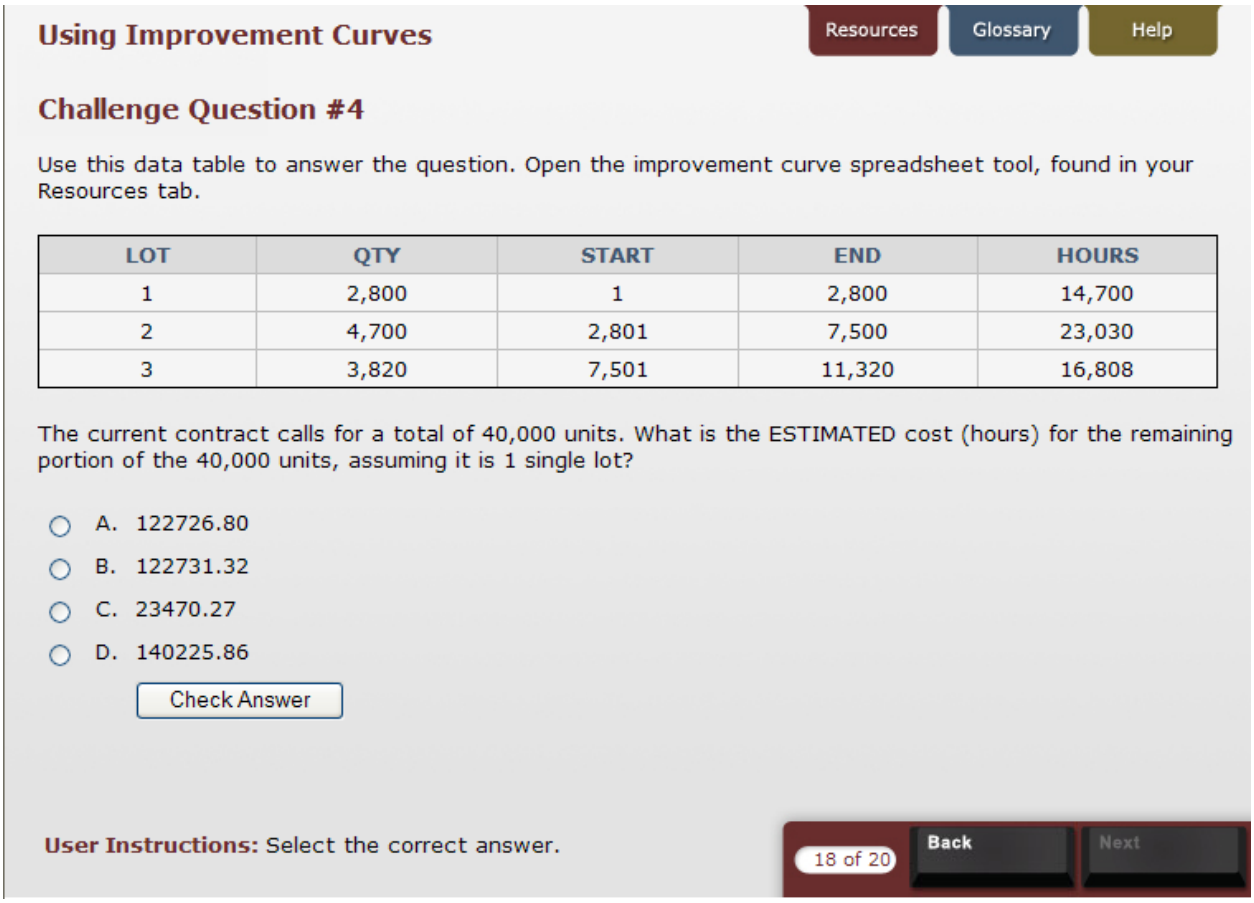

Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CAPTIONS
for major renovations such as replacement of base HVAC units, and construction of large public works project such as dams and levees.
User Instructions: Select Next to continue.
15 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CC
CAPTIONS
I have used it quite often myself - when buying light tactical vehicles.
User Instructions: Select Next to continue.
15 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
REWIND
PLAY
CC
CAPTIONS
There's even a handy spreadsheet tool that will calculate the slope for you, among other values. I'd like it to show you. Let's get started!
User Instructions: Select Next to continue.
15 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
(Instructional Use Only)
Historical Data Inputs
Production Lot #
# of Observations
First Unit
Last Unit
Lot Size
LMP (X)
Lot Cost (hrs)
AUC (Y)
0
Mean
#DIV/0!
Estimates
Production Lot #
# of Observations
First Unit
Last Unit
Lot Size
LMP (X)
Lot Cost (hrs)
AUC (Y)
#VALUE!
#VALUE!
#VALUE!
#VALUE!
User Instructions: Select Next to continue.
16 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
A Note From Matt
Hi,
I just wanted to tell you that you're really doing a great job so far. You must be a quick learner!
I hope our meeting in the conference room helped you to understand the improvement curve spreadsheet tool. You can find the Learning Curve Tool on the Defense Acquisition University's Acquisition Community Connection in the Contract Cost, Price and Finance Community of Practice at:
https://acc.dau.mil/CommunityBrowser.aspx?id=285813&lang=en-US.
Let me know if you have any questions!
Matt
User Instructions: Select Next to continue.
17 of 20
Back
Next



Using Improvement Curves

Resources Glossary Help

Challenge Question #4

Use this data table to answer the question. Open the improvement curve spreadsheet tool, found in your Resources tab.

LOT	QTY	START	END	HOURS
1	2,800	1	2,800	14,700
2	4,700	2,801	7,500	23,030
3	3,820	7,501	11,320	16,808

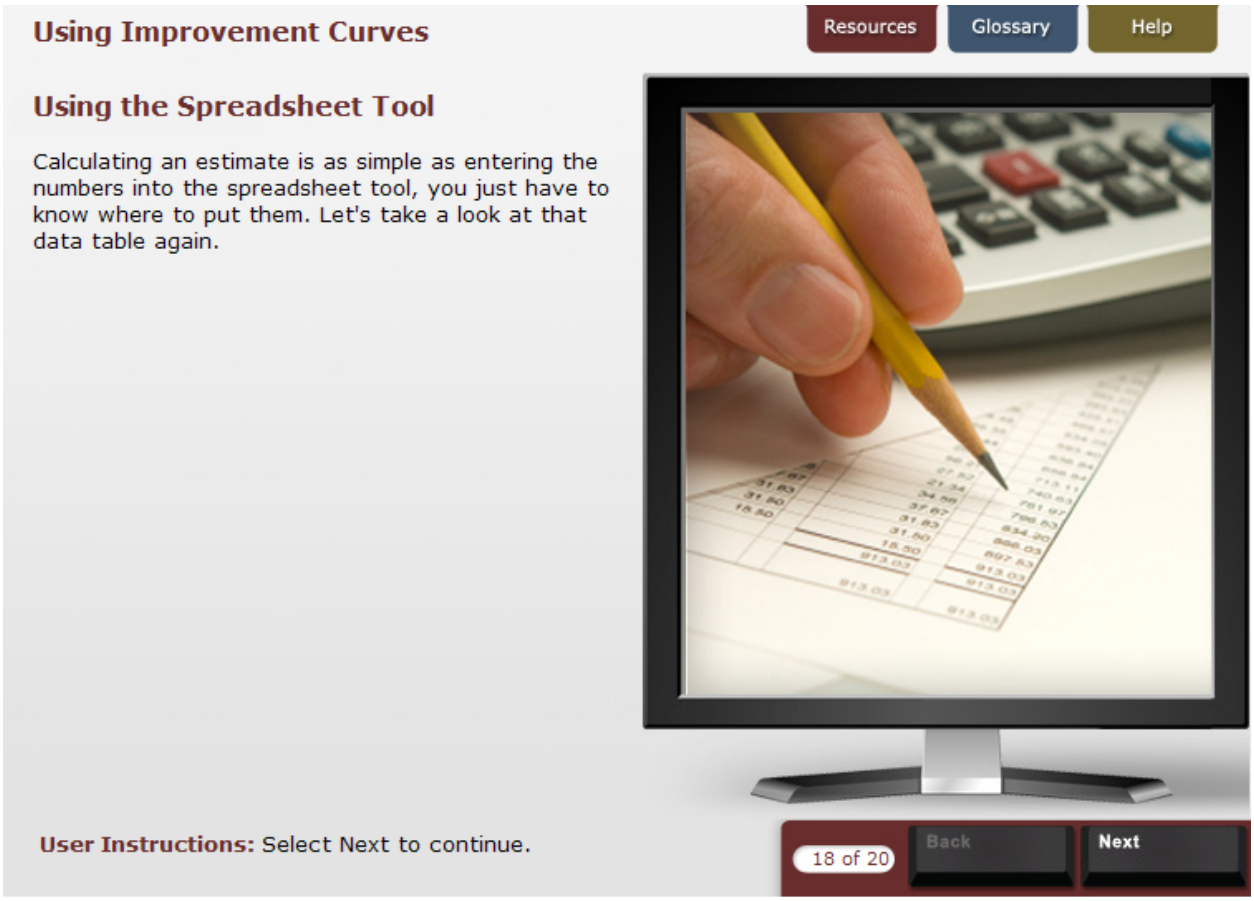
The current contract calls for a total of 40,000 units. What is the ESTIMATED cost (hours) for the remaining portion of the 40,000 units, assuming it is 1 single lot?

- A. 122726.80
- B. 122731.32
- C. 23470.27
- D. 140225.86

Check Answer

User Instructions: Select the correct answer.

18 of 20 Back Next


Using Improvement Curves
Resources
Glossary
Help
Using the Spreadsheet Tool
Calculating an estimate is as simple as entering the numbers into the spreadsheet tool, you just have to know where to put them. Let's take a look at that data table again.
User Instructions: Select Next to continue.
18 of 20
Back
Next

Using Improvement Curves

Resources | Glossary | Help

Using the Spreadsheet Tool (cont.)

The first thing you want to do is fill in the data that you already have. Looking at the table, we know that the first and last units of lot 1 are 1 and 2,800, respectively.

We also have the lot cost data for lot 1 so you can fill that into your spreadsheet now.

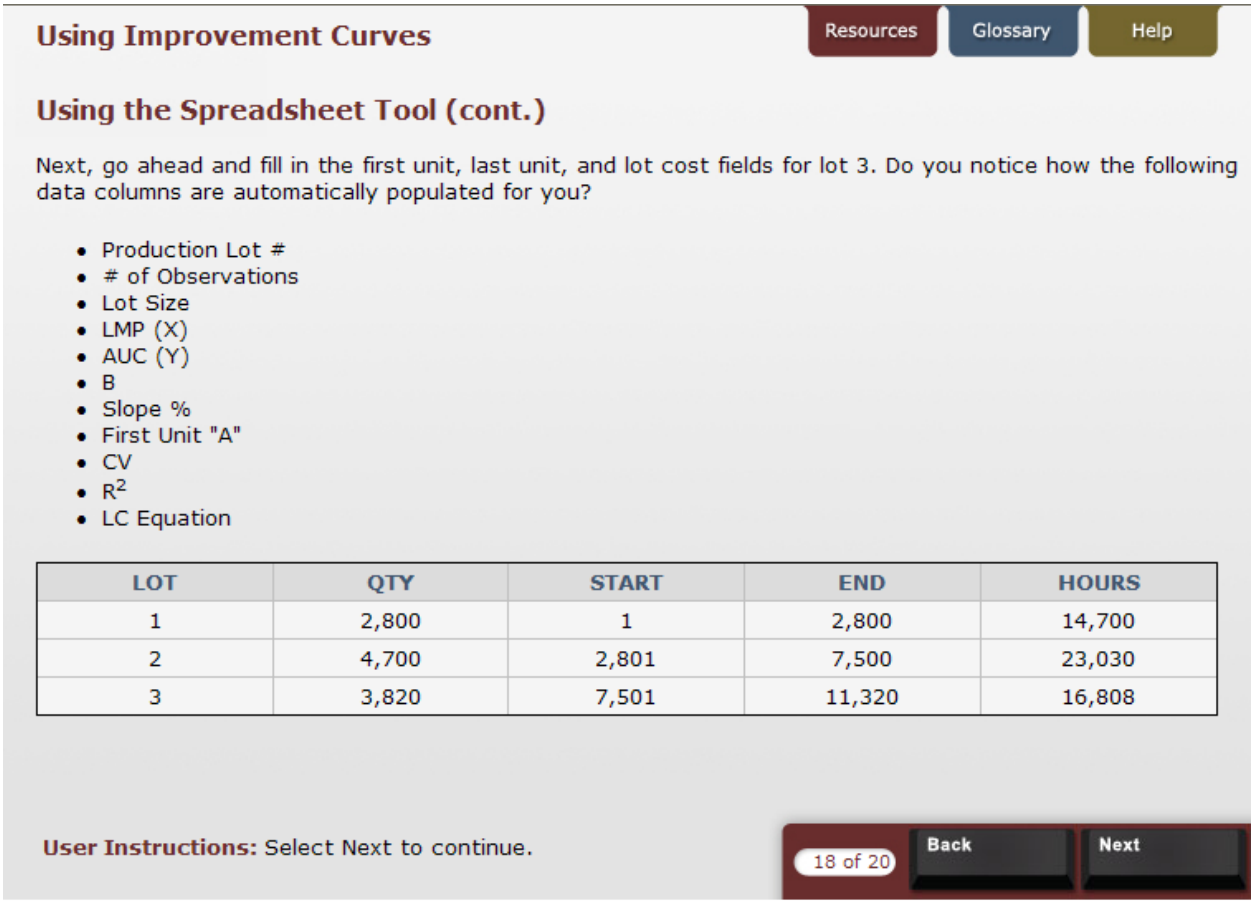
Since lot 1 included all units from 1 through 2,800, we know that lot 2's first unit will be 2,801.

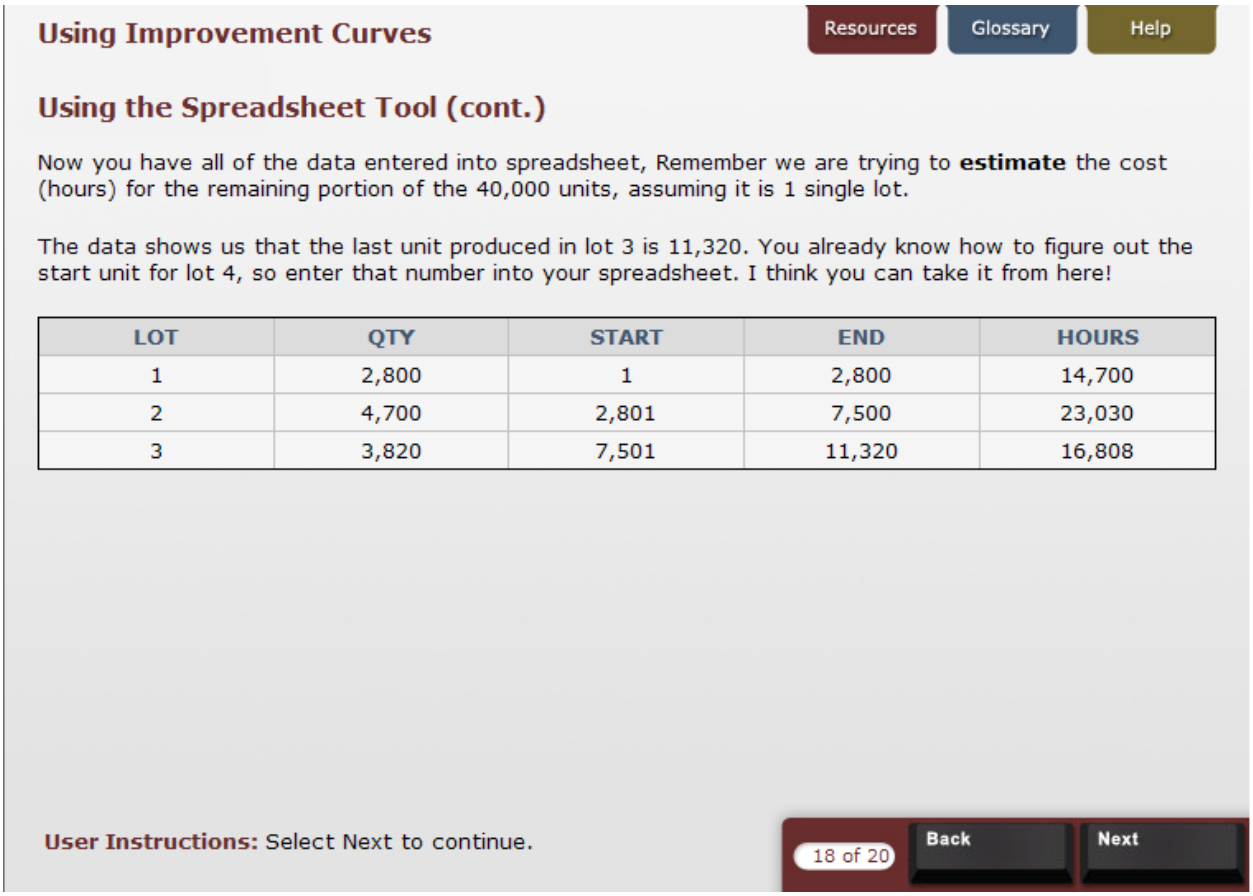
Remember, to find the first unit of a lot simply add a 1 to the previous lot's last unit. Enter the lot cost data for lot 2 into your spreadsheet.

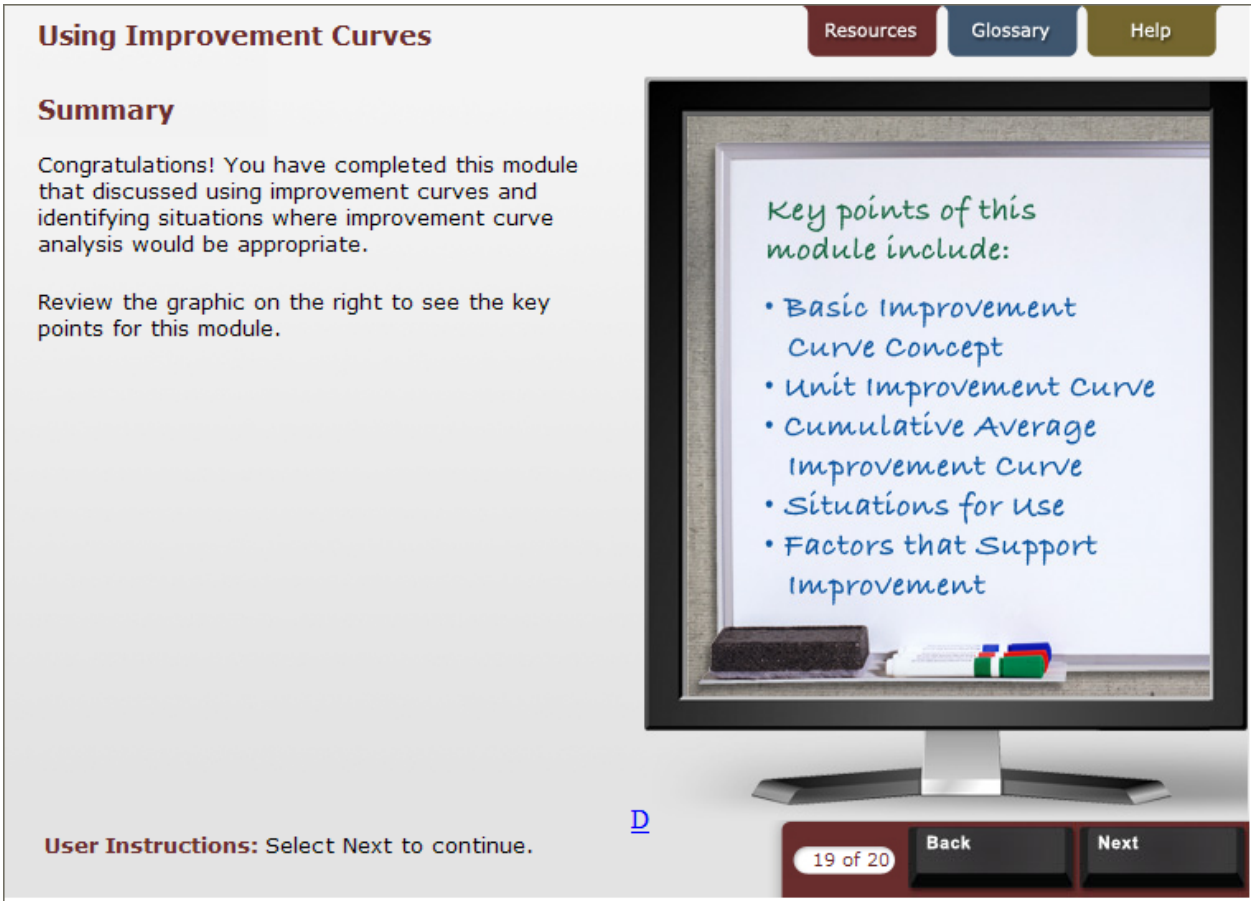
LOT	QTY	START	END	HOURS
1	2,800	1	2,800	14,700
2	4,700	2,801	7,500	23,030
3	3,820	7,501	11,320	16,808

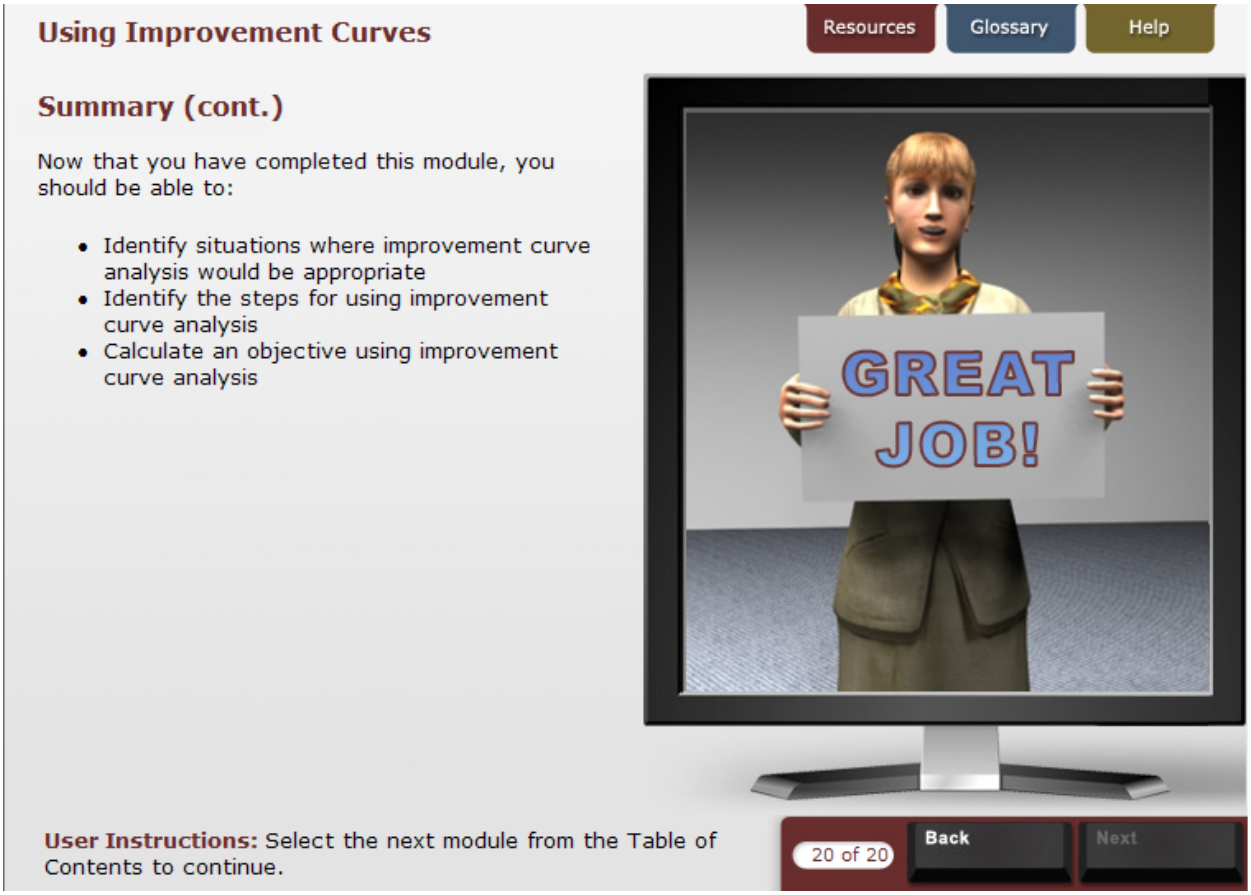
User Instructions: Select Next to continue.

18 of 20 Back Next


Using Improvement Curves
Resources
Glossary
Help
Using the Spreadsheet Tool (cont.)
Next, go ahead and fill in the first unit, last unit, and lot cost fields for lot 3. Do you notice how the following data columns are automatically populated for you?
Production Lot #
# of Observations
Lot Size
LMP (X)
AUC (Y)
B
Slope %
First Unit "A"
CV
R2
LC Equation
LOT QTY START END HOURS
1 2,800 1 2,800 14,700
2 4,700 2,801 7,500 23,030
3 3,820 7,501 11,320 16,808
User Instructions: Select Next to continue.
18 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Using the Spreadsheet Tool (cont.)
Now you have all of the data entered into spreadsheet, Remember we are trying to estimate the cost (hours) for the remaining portion of the 40,000 units, assuming it is 1 single lot.
The data shows us that the last unit produced in lot 3 is 11,320. You already know how to figure out the start unit for lot 4, so enter that number into your spreadsheet. I think you can take it from here!
LOT QTY START END HOURS
1 2,800 1 2,800 14,700
2 4,700 2,801 7,500 23,030
3 3,820 7,501 11,320 16,808
User Instructions: Select Next to continue.
18 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Summary
Congratulations! You have completed this module that discussed using improvement curves and identifying situations where improvement curve analysis would be appropriate.
Review the graphic on the right to see the key points for this module.
Key points of this module include:
• Basic Improvement Curve Concept
• Unit Improvement Curve
• Cumulative Average Improvement Curve
• Situations for Use
• Factors that Support Improvement
D
User Instructions: Select Next to continue.
19 of 20
Back
Next


Using Improvement Curves
Resources
Glossary
Help
Summary (cont.)
Now that you have completed this module, you should be able to:
• Identify situations where improvement curve analysis would be appropriate
• Identify the steps for using improvement curve analysis
• Calculate an objective using improvement curve analysis
GREAT JOB!
User Instructions: Select the next module from the Table of Contents to continue.
20 of 20
Back
Next