Preliminary Assessment Results

Agricultural Economics 339: Quantitative Methods and Decision Making

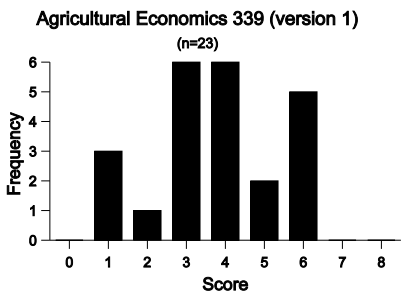
Fall 2000-01

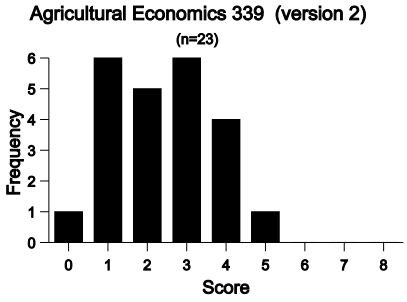
Forty-six students took two versions of a eight-item free-response test in Agricultural Economics 339 (Professor Lambert) during the first three weeks of the Fall 2000 semester. The test was designed to see the extent to which students had quantitative skills required for success in the course. Graduate students from the Department of Mathematics graded the papers, recording information about steps students had taken when solving the problems. The graders also coded the degree of success achieved on each problem using the following rubric:

A Completely correct
B Essentially correct—student shows full understanding of solution and only makes a minor mistake (e.g., wrong sign when calculating a derivative or arithmetic error)
C Flawed response, but quite close to a correct solution (appears they could do this type of problem with a little review or help)
D Took some appropriate action, but far short of a solution
E Blank, or nothing relevant to the problem

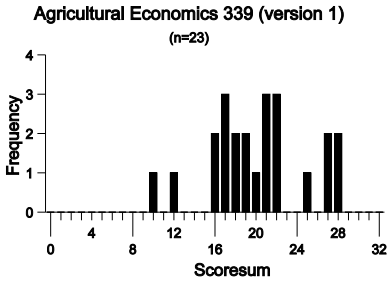
Corrected papers, along with suggested solutions to the problems, were returned to students the following week. Summaries of the grader's coding are included on the attached copy of the test.

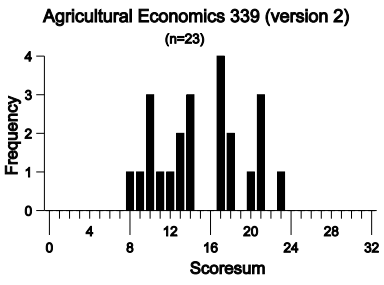
A test score was computed by awarding one point for each A or B code and zero points for each C, D, or E code. This score reflects the number of problems that each student had essentially or completely correct. The distributions of test scores are shown in these figures. The second pair of charts gives the distribution of partial credit scores called scoresum (each problem was awarded 0-4 points, E=0 to A=4).





These scores suggest there were some differences between the difficulty of the two tests or between the groups of students who took each version, since the scores are slightly higher on the first. It appears that many students will need to review some mathematics covered on the test, since a majority were successful on fewer than half the problems.





The problems are ranked according the degree of success students achieved on each problem in the following table.

Degree of Success on Test Problems

%AB	%A	%C	No	Problem description
100%	96%	0%	V1#6	Compute the mean of five data points
87%	35%	9%	V1#3	Solve an exponential equation
74%	35%	22%	V1#7	Complete and interpreting information given in a spreadsheet
57%	44%	13%	V1#4	Maximize profit given average and marginal cost
48%	22%	30%	V2#8	Complete and interpret a spreadsheet
44%	39%	26%	V2#5	Compare distribution for two seven point data sets
44%	39%	26%	V2#6	Plot line of best fit and estimate its slopes from scatterplot
39%	39%	35%	V1#8	Determine the change in slope due to deletion of one data point
35%	35%	4%	V2#3	Compute standard deviation for three data points with provided formula
30%	30%	61%	V2#2	Solve for the derivative of a cubic function
22%	22%	9%	V2#4	Use graph to obtain information about maximum value of a profit function
22%	17%	30%	V1#2	Interpret data presented in table form
17%	4%	9%	V2#7	Use normal distribution approximation
13%	13%	39%	V1#1	Solve a 2X2 linear system and plot the curves
9%	4%	70%	V1#5	Estimate values of a function and its derivative from a graph
0%	0%	17%	V2#1	Estimate values of a function and its derivative from a graph

The problems are primarily sorted in this table by proportion of students who received a code of A or B, indicating t at least essentially correct. For reference, the second and third columns report the proportion of students who had th completely correct (A, column 2) and the proportion who made good progress (C, column 3).

The problems have been divided into three groups. Three-fourths of the students were able to successfully compute means, solve exponential equations, and interpret spreadsheets. Around half of the students (30% to 57%) were able to solve problems concerning maximum profit, interpret a spreadsheet, compare statistical distributions, estimation of and change in slope, estimate slopes of lines of best fit, and find the derivatives of a cubic function.

Fewer than a quarter of the students were able to maximize profit using a graph of a profit function, interpret tables, make normal distribution approximations, solving and plot 2x2 linear systems, or estimate values of a function and its derivative from a graph.

Mathematics Backgrounds

University records provided information about the mathematics and statistics courses that had been taken by students in these classes. The following tables report up to the four most recent math and statistics courses recorded on each student's transcript. These data reveal that many students had completed at least two university mathematics and/or statistics classes. The second version of the test appears more difficult; there is little apparent connection between prior course grades and test scores for this version. On the second version it appears that "A" and "B" students were more successful. Nearly every student for each test version had completed the co-requisite course, Statistics 330, with a satisfactory grade of "C" or better. The mean grade for those who had completed Statistics 330 was a low B for both versions.

College Level Mathematics and Statistics Courses (Four Most Recent Courses)

Score (max=9)	Scoresum (max=32)	Version	Math Courses (Course—Semester—Grade*)
6	28	1	S331 003 A
6	28	1	S331 001 A S330 993 B M147 983 C M146 981 C
6	27	1	S330 003 B M103 991 A
6	27	1	S331 003 A M146 991 B S330 991 A M142 981 C
6	25	1	S462 004 B S368 003 B M420 001 B S367 001 A
5	21	1	S331 003 A S330 001 B M103 991 D
5	21	1	S330 003 B M103 001 C
4	22	1	S331 003 B S330 993 B M124 983 B
4	22	1	M103 001 B
4	22	1	S330 001 D M103 991 C
4	21	1	S331 993 B S330 991 B M103 981 C
4	19	1	S330 001 B S330 001 A M103 991 D
4	19	1	No data available
3	20	1	S331 993 A S330 983 A M103 964 A
3	18	1	S331 001 A S330 993 A M146 991 B M103 983 B
3	18	1	S330 001 B M103 993 C
3	17	1	S330 001 B M142 981 C
3	16	1	S331 003 A S330 001 B M103 993 C
3	16	1	S331 993 A S330 991 A M103 981 D
2	17	1	S330 993 B M103 983 C
1	17	1	S331 001 A S330 993 B M160 991 D
1	12	1	No data available
1	10	1	M103 003 C M102 993 B
5	23	2	S331 993 A S330 991 A
4	21	2	S330 003 B
4	21	2	S330 003 A M103 993 A
4	17	2	S330 001 A M146 991 C
4	17	2	No data available
3	21	2	S331 004 A M330 001 B
3	20	2	S330 003 B M103 991 B
3	18	2	S330 003 B M103 993 B
3	18	2	S331 003 A S330 001 B M103 991 B
3	17	2	S331 003 A S330 001 B
3	17	2	S331 003 A S330 001 A M146 993 A
2	14	2	S331 993 C S330 991 C M103 981 B
2	14	2	S331 991 B M146 981 C
2	14	2	S331 003 A S330 001 A M103 991 B
2	13	2	M146 993 B M103 991 C S331 983 C
2	10	2	S331 003 B S330 001 B M103 983 C
1	13	2	S330 003 B
1	12	2	S330 003 B M103 001 D M102 993 B
1	11	2	S330 003 C M103 001 C M102 993 C
1	10	2	Data not available
1	10	2	Data not available
1	8	2	S330 003 C
0	9	2	Data not available

NDSU Mathematics and Statistics Courses

M100-M102 Pre College Algebra
M103 College Algebra
M142 Trigonometry
M124 Finite Math
M146-M147 Business Calculus Sequence
M160-M161, M260 Regular Calculus Sequence
M261 Differential Equations

Reactions

We asked the instructor five questions about the test results. His responses are summarized below.

Instructors:

1. Are you surprised by students' performance on particular test items?

- I was not greatly surprised by low number of A&B answers on questions to evaluate f(x) or f'(x). Combined with the poor responses in taking the derivative of the polynomial in V2#2, though, it seems students are not well trained in understanding conceptual basis of functional analysis and calculus (at least derivatives).

2. Did you do anything different this semester because of your students' performance on the test?

- I did work through a few unconstrained optimization problems by hand, which I may not have done had students done better on the assessment test. Since the course is computer (spreadsheet) based and doesn't require use of calculus explicitly I did not dwell on calculus drills.

3. How well do you think the tests reflected the quantitative demands of your course? Is it accurate to say that the skills we testes were essential for survival in the course?

- Ths skills tested were not essential for the course. The purpose of the assessment was more of a snapshot of student skills in our major. Thus, student difficulty in deriving marginal cost functions and finding profit maximizing levels of production is troubling since these are basic components of applied economics.

4. Would you suggest any changes in prerequisites, student preparation, or the nature of this course based on what you have learned from the preparation and administration of these tests?

- No. What we are going to do is incorporate greater use mathematics in all of our courses. Students do get some calculus in either AGEC 150 or Math 146. However, they apparently do not use it beyond these courses. This will change.

5. If this or another course in your department was tested again in another semester, would you suggest any changes in the testing program?

- No, you administered a very useful test that provides us with good feedback on where we need to improve our students' math skills.

*Oth*er Comments

- Only that I appreciate what you are doing and that we will be upgrading math use in our courses to try to improve student performance on future assessment tests.

Department:

Reactions to these results:

Suggested responses(action plans):

Percentages refer to the proportions of the 23 students who took the test.

1. (a) Sketch the graph of this system of equations on the provided grid:

$$\begin{cases} x - y = 1 \\ x - 3y = -15 \end{cases}$$

(b) Find the values of x and y that satisfy both equations.

Correctly eliminated one variable:	39%
Correctly finds one coordinate of the point of intersection:	35%
Correctly finds solution of the system:	30%
Correctly marks both y-intercepts (not essential):	30%
Correctly marks both x-intercepts (not essential):	0%
Correctly marks point of intersection (not essential):	9%
Correctly plots slopes – this requires (any) two points per line (essential)	39%

Degree of Success: A 13% B 0% C 39% D 17% E 31%

2. A Media professor asked the 126 students in his class whether or not they read *Time* or *Newsweek* the previous week. The students' responses are summarized in this table:

		Time	
		Yes	No
Newsweek	Yes	41	23
	No	52	10

(a) How many students said they read *Time* the previous week?

Selects correct numbers: *44%*
Gives correct total: *44%*

(b) How many students did not read either magazine the previous week?

Selects correct numbers: *87%*

(c) How many students said they read at least one of the news magazines the previous week?

Selects correct numbers: *22%*
Gives correct total: *22%*

Degree of Success: A 18% B 4% C 30% D 35% E 13%

3. The number of bacteria in a culture doubles every eight hours. The number of bacteria present, A, after t hours is given by the formula

$$A = 500 \times 2^{\frac{t}{8}}$$

(a) How many bacteria are present after 48 hours?

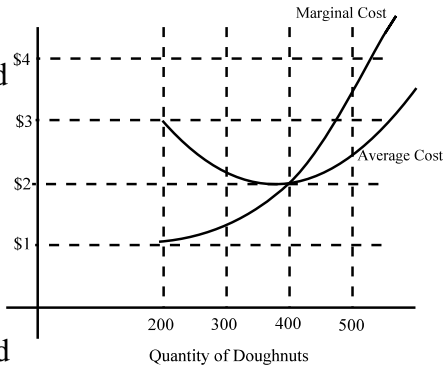
Substitutes 48 into formula correctly: 96%
Simplifies correctly: 91%

(b) After how many hours will the culture contain at least 4000 bacteria?

Substitutes 4000 into formula correctly: 96%
Solves resulting equation for t correctly: 35%

Degree of Success: A 35% B 52% C 9% D 4% E 0%

4. Use the bakery cost information in the graph to answer the following questions:



a) To maximize profit at a price of $3, how many doughnuts should the bakery produce? Why?

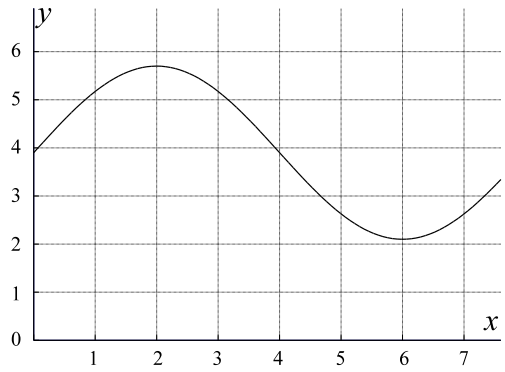
Correctly estimated near 475
(accepted responses 450 < x < 490): 57%
Indicated that marginal cost was equal to marginal price at that point: 52%

b) To maximize profit at a price of $2, how many doughnuts should the firm produce? What are the firm's profits at this level of output?

Correctly estimated near 400 (accepted responses 370 < x < 410): 96%
Correctly stated that there is no profit at this level: 61%

Degree of Success: A 44% B 13% C 13% D 26% E 4%

5. Here is the graph of a function ***y = f(x)***. Use it to estimate answers to these questions as accurately as you can.



(a) For what value(s) of ***x*** is the function decreasing?

Gives correct interval (about 2< x < 6): 74%
Incorrectly gives intervals for where the function is increasing: 4%

(b) For what value(s) of ***x*** is the function's graph concave downward?

Gives correct interval (about 0 < x < 4): 48%

(c) At what value of *x* is the function decreasing most rapidly?

Correctly indicates at the inflection point (about x = 4): 61%
Incorrectly gives the relative minimum (at about x = 6): 4%

(d) Estimate the maximum and minimum values of the function over the interval [0,7].

Correctly estimates maximum about y = 5.7: 39%
Incorrectly gives x value for maximum (about x = 2): 22%
Correctly estimates minimum about y = 2.1: 44%
Incorrectly gives x value for minimum (about x = 6): 17%

(e) For what values of *x* over the interval [0,7] is $f^{(1)}$ *positive*? (NOTE: $f^{(1)}$, the first derivative of f, can also be written as $\frac{dy}{dx}$ or f')

Gave correct intervals (about x < 2 or x > 6): 17%
Incorrectly gave intervals for where the function is decreasing: 4%

Degree of Success: A 4% B 4% C 70% D 22% E 0%

6. Compute the sample mean (average) of the following data set: {1, 1, 2, 4, 7}

Makes a computational error: 4%
Reports the mode (1) 0%
Reports the median (2) 0%

Degree of Success: A 96% B 4% C 0% D 0% E 0%

7. A television station tracks the viewing habits of 1000 households. The average number of these households that have a television set tuned to the station during various viewing periods are given in this spreadsheet. (In this program, letters identify columns and numbers identify rows. For example, cell F4 contains the number 350.)

	D	E	F	G	H	I
3	*Time Slot*	*Spring*	*Summer*	*Autumn*	*Winter*	*Average for time slot*
4	*Late afternoon*	380	350	450	500	
5	*Prime time*	410	420	450	440	
6	*Late evening*	240	250	270	290	
7	*Average for season*					

(a) If the cursor were in cell E7, write a formula using cell addresses that would instruct the spreadsheet to calculate the average number of households tuned to the station in the spring.

Gives an appropriate formula (there are several possibilities): *83%*

(b) During which viewing period (season and time slot) do the fewest households tune to this station? Give the average number of households tuned to the station at that time.

Identifies the correct season and viewing period: *83%*
Gave the correct number (240): *57%*

(c) During which season does the station have the highest average number of households tuned to its broadcasting?

Gave the correct season (winter): *100%*

(d) In which cell would the average number of households tuned to the station during *prime time* be computed? Give a spreadsheet formula, using cell addresses, that would compute the correct average.

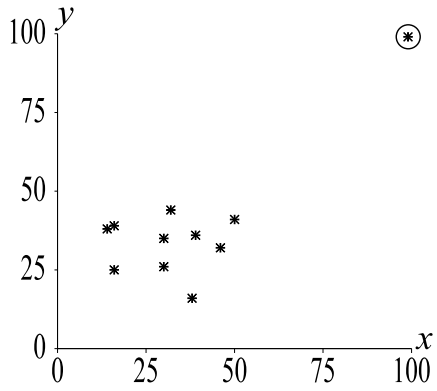
Gave the correct cell address: 87%
Gave an appropriate formula (there were several possibilities): 83%

Degree of Success: A 35% B 39% C 21% D 4% E 0%

8. (a) The scatterplot contains eleven cases with the point for one case circled. This creates two data sets:

- Data set 1: All eleven cases.
- Data set 2: The ten cases remaining after deleting the circled case.

Two linear regression analyses were conducted over the two data sets. One of the data sets resulted in a slope of +1.0 and the other had a slope of +0.2. Match the data sets with the slopes.

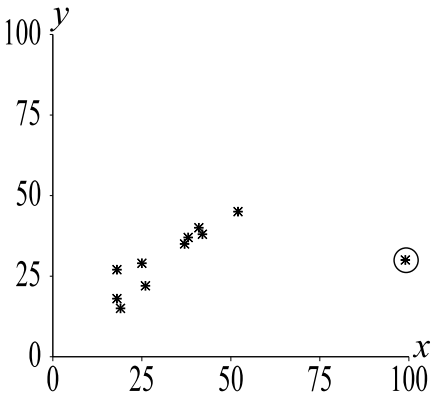


Reversed slopes:	9%
Gave no labeling - said cannot tell:	26%
Gave correct slopes:	44%

(b) The scatterplot contains eleven cases with the point for one case circled. This creates two data sets:

- Data set 1: All eleven cases.
- Data set 2: The ten cases remaining after deleting the circled case.

Two linear regression analyses were conducted over the two data sets. One of the data sets resulted in a slope of +1.0 and the other had a slope of +0.2. Match the data sets with the slopes.

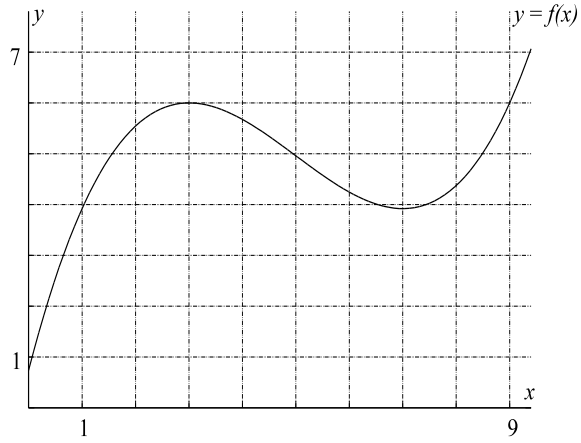


Reversed slopes:	9%
Gave no labeling - said cannot tell:	26%
Gave correct slopes:	44%

Degree of Success: A 39% B 0% C 35% D 0% E 26%

Percentages refer to the proportions of the 23 students who took the test.

1. Here is the graph of a function $y = f(x)$. Use the graph to estimate these values as accurately as you can: (Recall that if $y = f(x)$ then $\frac{dy}{dx} = f'(x)$)



(a) $f(3)$

Estimated correct value (about 6): *35%*

(b) $f'(7)$

Commented on local maximum and/or horizontal tangent x = 7: *9%*
States m = 0 at x = 7: *0%*

(c) $f'(1)$

Observes that the gradient at x = 1 is positive: *0%*
Estimates 1 < m < 3 at x = 1: *9%*

(d) For which values of *x* in the interval [0,9] is $f'(x)$ *negative*?

Correctly estimates interval 3 < x < 7: *26%*
Incorrectly gives intervals where the function is increasing: *4%*

(e) What is the minimum value for $f(x)$ on the interval [0,9]?

Correctly states y = 0.8: 39%
Incorrectly gives y = about 4 (another local minimum): 13%
Incorrectly gives x coordinate (either 0 or 7): 9%

Degree of Success: A 0% B 0% C 17% D 44% E 39%

2. Marginal cost is the derivative of the total cost function. If the total cost function is $T = 100x - x^2 + 0.01x^3$, find the marginal cost function.

Attempts to differentiate the given total cost function: 96%
Correctly differentiates that total cost function: 30%

Degree of Success: A 30% B 0% C 61% D 5% E 4%

3. Compute the sample standard deviation of the following data set: {0, 2, 4}
   A formula for computing the sample standard deviation is

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

   where $\bar{x}$ is the sample mean and *n* is the number of observations.

Answer only, no apparent computations (possibly indicating use of calculator) 4%

Degree of Success: A 35% B 0% C 4% D 31% E 30%

4. The function on this graph gives the profit, ***P(x)***, made by an agricultural chemical company in a week if they make and sell ***x*** bags of fertilizer. They are able to produce ***at most*** 2500 bags of fertilizer each week.

   (a)Use the graph to determine the range of weekly production levels that would be profitable for this manufacturer. ***Explain how you arrived at your answer***.

Accurately estimates lower bound (x-intercept): *44%*
Gives the exact upper bound: *44%*
Gives a correct written explanation, e.g. noting that profitability corresponds to positive function values 2000 *22%*

   (b)Use the graph to estimate the number of bags that should be produced and sold each week to earn the largest profit.

Accurately estimates x value corresponding to maximum: 91%
Incorrectly states maximum profit (around $35,000) rather than the number of chairs that give a max: 0%

Degree of Success: A 22% B 0% C 9% D 65% E 4%

5. You are given the following consecutive monthly rates of return (expressed in percents) on two securities.

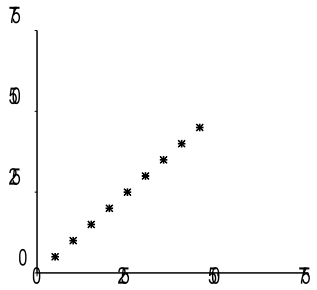
Security	Rates of Return
A	3, 5, 14, 9, 11, 6, 7
B	3, 4, 14, 9, 13, 6, 7

Which set of returns has the larger mean? Which set has the larger standard deviation? Back up your answers with pertinent analysis.

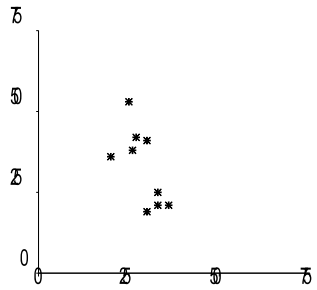
Makes a dot diagram (not necessary): 0%
Computes means (not necessary): 78%
Computes standard deviations (not necessary): 39%
Compares standard deviations: 52%

Degree of Success: A 39% B 4% C 26% D 31% E 0%

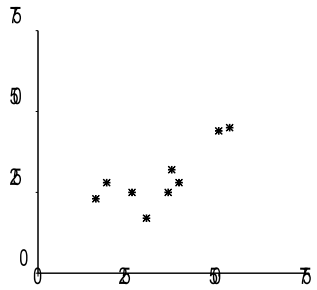
6. Below are three scatterplots.. On each plot, sketch a straight line that best fits the plotted points. Then estimate the slope of each line as accurately as you can and write it below the graph.



Estimated slope:



Estimated slope:



Estimated slope:

Reasonable line of best fit for first plot: 96%
Good estimate of slope of the line they drew: 74%
Reasonable line of best fit for second plot: 70%
Good estimate of slope of the line they drew: 39%
Reasonable line of best fit for third plot: 83%
Good estimate of slope of the line they drew: 57%

Degree of Success: A 39% B 4% C 26% D 22% E 9%

7. A study reports the heights of a group of 1000 college women. It states that the sample mean is 65 inches, the sample standard deviation is 2.5 inches and the distribution of heights is approximately `bell-shaped'. Approximately how many of the women are between 60 and 70 inches tall?

Indicated use of ""empirical rule for the standard deviation": 30%
Indicated desired proportion was within 2 standard deviations of the mean: 17%
Stated this was about 95% of the sample: 13%

Degree of Success: A 4% B 13% C 9% D 22% E 52%

8. A farm supply store uses a simple spreadsheet program to keep track of sales. A sample entry is given below. The first item has already been completed. The contents of a cell in this program are referenced by using the letter of the column and the number of the row. For example, the unit cost of posts, $3.20, is in cell B3. Values in columns D-G are computed using the numbers entered in columns B and C. For example, the *retail cost* for fencing in E2 could be computed using this formula:

B2*C2 + 0.20*B2*C2

(* means multiplication in this program, + is addition, - is subtraction, and / is division)

	A	B	C	D	E	F	G
1	*Item*	*Unit Cost*	*Quantity*	*Markup (20%)*	*Retail Cost*	*Tax (5.5%)*	*Net*
2	*Fencing*	$12	100	$240	$1440	$79.20	$1519.20
3	*Posts*	$3.20	100				
4	*Nails*	$0.30	500				
5	*TOTAL*						

Use this table to answer the following questions:

(a) How many posts were ordered?

Gave the correct number (100): *96%*

(b) The following formula, located in cell E2, was used to compute the correct value for cell E2:

B2*C2 + D2

How should the formula be changed so that it computes the correct value for cell E4?

Correctly altered the formula (changed 2's to 4's): *74%*

(c) Assume that all the cells D3-F3 have been computed in the posts row (row 3). Write a formula, using cell addresses (e.g., B3) for other cells in row 3, that gives the correct value for cell G3.

Gave a correct formula (there were several possibilities): *78%*

(d) Assume that values in columns D and E have already been computed correctly. Write a formula, using cell addresses, that computes the tax on nails (column F). In which cell should your formula be entered?

Gave a correct formula (there were several possibilities): *78%*
Identified the correct cell (F4): *57%*

(e) Find the values for the blank cells in column G and then compute the correct net total for these three items. (i.e., the value that belongs in cell G5).

Gave correct value in cell G3: 70%
Gave correct value in cell G4: 61%
Gave correct value in cell G5 based on numbers in G3 and G4: 83%

Degree of Success: A 22% B 26% C 30% D 22% E 0%