Frederick Community College

Assessment of Student Learning

Mathematics Department

3rd Assessment Cycle 2012-2015

Final Assessment Report

Quantitative Reasoning and Critical Thinking

Statistics (MA 206)

Prepared By

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Background

As part of the third Outcomes Assessment Cycle, the Mathematics Department chose to assess statistics (MA206). As part of the assessment process, all MA206 students were assessed using a pre- and post-test format.

> Course Description: *MA206 – Elementary Statistics,* is an introductory non-calculus statistics course. Topics include descriptive analysis and treatment of data, probability, statistical inference, linear regression and correlation, chi-square tests, and non-parametric tests.

The department chose to assess students' critical thinking and quantitative reasoning skills as part of the assessment to meet the requirements of the Maryland Higher Education Commission and the Middle States Commission on Higher Education. Additionally, including these competencies in the assessment would allow the Mathematics Department to better understand student learning and improve students' critical thinking and quantitative reasoning skills through pedagogical changes.

MA206 was chosen because it is a high-enrollment class that students take to fulfill their General Studies or Major requirements. The course has the largest enrollment of any General Education Mathematics course (approximately 400 students each semester). Additionally, the course learning outcomes align with Frederick Community College's General Education Competencies.

Methodology

MA206 – Elementary Statistics is an introductory non-calculus statistics course. Topics include descriptive analysis and treatment of data, probability, statistical inference, linear regression and correlation. MA206 students learn by engaging in classroom and homework activities that investigate statistical concepts from the graphical, symbolic, numerical, and verbal points of view. Responses to a pre-post test with 14 questions were collected (Appendix A) and submitted to a database using a FCC web portal. A few sections in the Spring 2013 semester were used to collect a baseline score. The OAC representatives devised a grading rubric and a point system during the pilot phrase to ensure consistence in grading. Beginning Fall 2013, all MA206 classes participated in the third assessment cycle.

Each instructor involved was also given a grading rubric (Appendix B) to ensure consistency of scores across all sections

Neither individual students nor instructors were identified in any of the assessment reports.

Analysis of Data

The artifact (test) was designed so that the sequence of required responses was natural and easy for the student. Each competency was evidenced at places throughout the artifact (test). This presented two challenges for the team, who were required to align separate learning evidence by competencies, as well as assure consistency in scoring.

The department addressed that both of these requirements were met by the use of **example artifacts**. The team devised and revised a point grading scheme during the initial pilot phase of the process. The collection of examples, after being agreed upon by the team, served as the main resource for answering a scorer's question: "How should I score something like this?" They served as the definitive scoring calibrator--even should the makeup of the assessment team change.

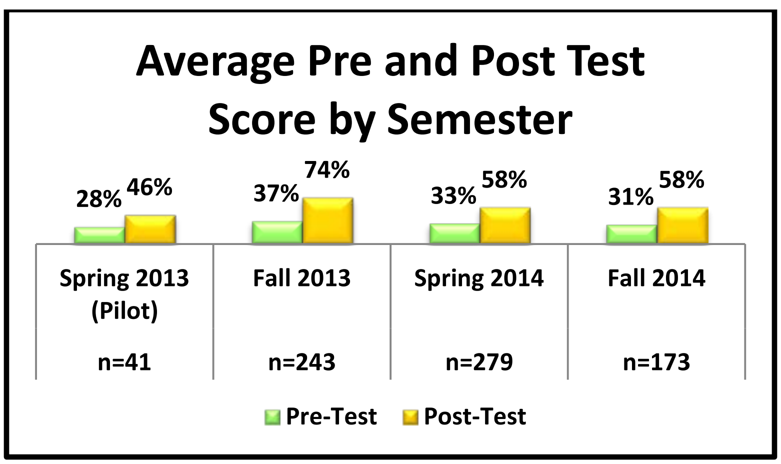
Once these requirements had been addressed and data has been collected, it was submitted using the college's online assessment form. The online form allows faculty to log directly into the system and submit their roster's records. This data was then pulled into SPSS (Statistical Package for the Social Sciences) and the analysis was completed by the Senior Researcher, Assessment and Institutional Effectiveness. Once the data was compiled, a report was sent to the OAC representative and shared with the department.

In each report, student competency distribution was analyzed and organized by assessment question and by total possible point per outcome assessed, comparing pre- and post- results. Based on our experience from the third assessment cycle, we have found this scheme effective to analyze student learning and identify strategies for helping students to learn.

Results

Student Average Score Growth or Decline Per Question: Pre and Post Test																	
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6a**	**Q6b**	**Q6c**	**Q6d**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**
Points Available	1	2	2	3	1	1	1	3	3	2	1	1	2	1	1	1	2
Question Type	QR	CT	CT	Both	QR	Both	Both	Both	Both	CT	QR	CT	QR	QR	CT	CT	Both
Median - Spring2013	.00	.00	.00	**1.74**	.00	.00	**1.00**	**.00**	**.00**	**1.00**	.00	**.00**	**.95**	**.00**	**.00**	**.00**	**1.00**
Median - Fall2013	.00	.00	.00	**1.00**	.00	.00	**1.00**	**1.00**	**1.00**	**1.00**	.00	**.00**	**1.00**	**.00**	**.00**	**1.00**	**1.00**
Median - Spring2014	.00	**1.00**	.00	**1.00**	.00	.00	**1.00**	**1.00**	**1.00**	**1.00**	.00	**.00**	**1.00**	**1.00**	**.00**	**1.00**	**1.00**
Median - Fall2014	.00	.00	.00	**2.00**	.00	.00	**1.00**	**1.00**	**2.00**	**2.00**	.00	**.00**	**2.00**	**.00**	**.00**	**.00**	**.00**

The above chart shows the growth of the average score per question, which is the Post-test minus the Pre-test score per question. The zero scores in red indicate no points were achieved in both the pre-tests and post-tests. Hence, these red scores show learning did not take place in the concepts covered by these questions. Questions 9, 11, 12, and 13 cover the topics of correlation, percentiles, standard deviation, and the Central Limit Theorem, respectively.



Overall, there is a significant increase in the post-test scores versus pre-test scores (all p-values are close to zero). This shows that learning is taking place. However, the post-test scores are not as high as the department would like to see.

Recommendations

The department has developed the following recommendations to help further improve student learning in the coming semesters.

(1) Create student activities to supplement the book's development of certain topics, especially correlation, percentiles, standard deviation, and the Central Limit Theorem.
(2) Design workshops to expose both full-time and adjunct instructors to different classroom activities and techniques to teach statistics.
(3) Find and disseminate online simulations to instructors for use in class to reinforce the topics being taught.

Further Research

The department hopes to design an assessment project based on the recommendations above to better understand student learning in the future. The data from this assessment will be used to develop additional learning and teaching strategies to improve students' critical thinking and quantitative reasoning skills in the upcoming semesters.

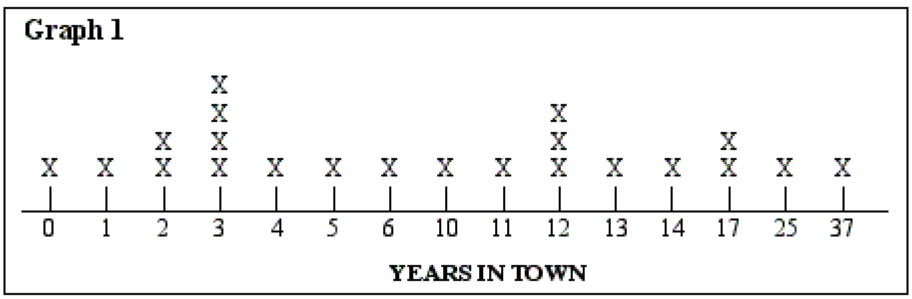
Appendix A

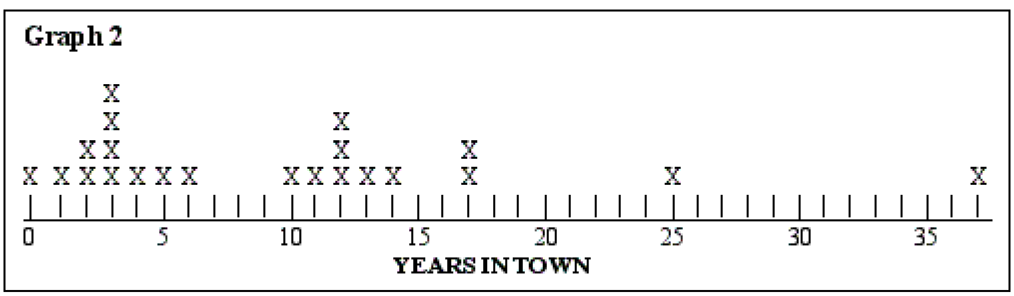
1. Suppose a particular outcome from a random event has a probability of .02. Which of the following statements represent correct interpretations of this probability?

   a. The outcome will never happen.
   b. The outcome will certainly happen two times out of every 100 trials.
   c. The outcome is expected to happen about two times out of every 100 trials.
   d. The outcome could happen, or it couldn't, the chances of either result are the same.

2. A class of students recorded the number of years their families had lived in their town. Here are two graphs that students drew to summarize the data. Which graph gives a more accurate representation of the data? ____________

   Why? Explain your reasoning in a complete sentence.





3. Four students at a local high school conducted surveys.
   - Shannon got the names of all 800 children in the high school and put them in a hat, and then pulled out 60 of them.
   - Jake asked 10 students at an after-school meeting of the computer games club.
   - Adam asked all of the 200 children in Grade 10.
   - Claire set up a booth outside of the school. Anyone who wanted to stop and fill out a survey could. She stopped collecting surveys when she got 60 students to complete them.

   Who do you think has the best sampling method?

   a. Shannon b. Jake c. Adam d. Claire

   Why? Explain your reasoning in a complete sentence.

4. The IQ (intelligence) scores of thirty-three students from the same third grade classroom are presented. One set is for boys and the other set is for girls. Summary statistics (mean, standard deviation, median, and quartiles) are provided for each set of children. Use the stems below to create a back-to-back stem-and-leaf plot so that you can visually compare the IQ scores of the boys with the IQ scores of the girls.

BOYS	GIRLS
113 113 122 116 122 134	115 102 119 114 108 111
134 105 122 126 129 133	122 113 125 118 96 112
122 133 108 120 144 104	124 122 115
$\bar{x}$ = 122.2 sd = 11.09 Q_1 = 113 Median = 122 Q_3 = 133	$\bar{x}$ = 114.4 sd = 8.05 Q_1 = 111.5 Median = 115 Q_3 = 120.5

BOYS		GIRLS
	9	
	9	6
4	10	2
8 5	10	8
3 3	11	1 2 3 4
6	11	5 5 8 9
2 2 2 2 0	12	2 2 4
9 6	12	5
4 4 3 3	13	
	13	
4	14	
	14	

Write a comparison of the distribution of IQ scores for the boys and girls that includes comparisons of shape, center, and variability.

5. One of the items on the student survey for an introductory statistics course was "Rate your intelligence on a scale of 1 to 10." The distribution of this variable for the 100 women in the class is presented below. What is the probability of randomly selecting a woman from the class who has an intelligence rating that is LESS than seven (7)?

a. (12 + 24)/100 = .36

b. (12 + 24 + 38)/100 = .74

c. 38/100 = .38

d. (23 + 2 + 1)/100 = .26

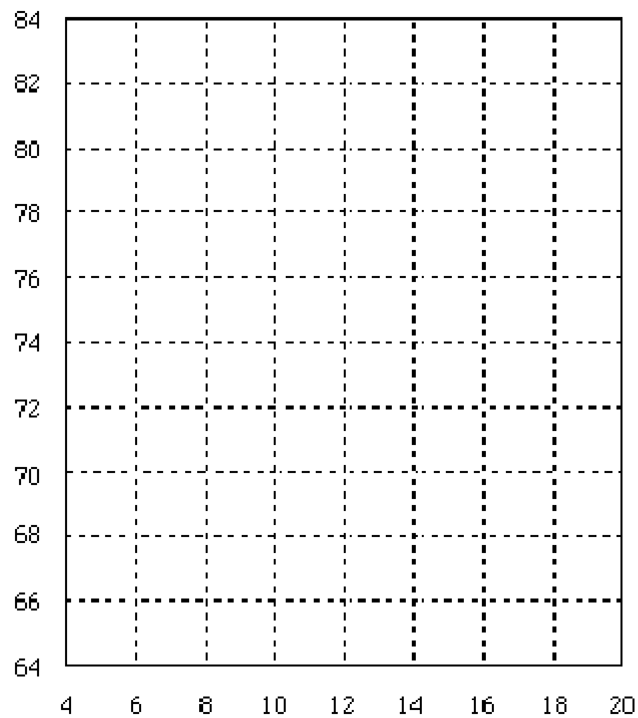
e. None of the above.

Intelligence Rating	Count
5	12
6	24
7	38
8	23
9	2
10	1

6. Ten states were randomly selected from among the 50 United States. This data set presents the percentage of households in each state that were below the poverty level (Poverty Rate) and the percentage of adults in the state who had earned a high school degree or higher (HS and Above). In the table is the mean and standard deviation for each variable, and the correlation for the two variables. You do not need to calculate these values.

Variable	Mean	Standard Deviation	Correlation
Poverty Rate	12.33	3.117	-.796
% HS and Above	76.11	6.176	

Poverty Rate	HS and Above
8.7	77.5
19.0	64.7
13.1	76.7
10.2	82.5
10.2	78.8
13.0	70.0
12.5	75.6
11.9	83.1



(a) Draw a scatterplot of the two variables using the grid provided.

(b) Use data above to get a linear regression equation. (You can either use your calculator or use the points (19, 64.7) and (10.2, 78.8) and the slope-intercept formula $y = mx+b$ to the get the equation.) Write the equation here.

(c) Using your regression equation, predict the percentage of adults with HS and above given a poverty rate of 9%. ___________ Does this prediction make sense? Why or why not?

(d) Using your regression equation, predict the percentage of adults with HS and above given a poverty rate of 25%. ___________ Does this prediction make sense? Why or why not?

7. a. Give an example of a research study that illustrates the placebo effect.

b. What is the purpose of the placebo in the context of the research study.

8. If you flip a fair coin and get heads 5 times in a row, what is the chance of getting tails on the next flip?

a. Greater than 50%

b. 50%

c. Less than 50%

9. The correlation between two scores on tests was found to be exactly 1. Which of the following would **NOT** be true, regarding the corresponding scatterplot?

a. Every point would lie along a perfect straight line, with no deviations at all.

b. The slope of the best fitting line would be 1.

c. The best fitting line would have an uphill (positive slope).

d. All of the above are true.

10. The distributions of SAT and LSAT scores are both approximately normal and symmetric. Veronica took both tests (at different times) and would like to know on which test her performance was better. Use the data given on each test to decide which score was better, relative to other people who took each test. **Explain your answer.**

Test	Veronica's score	Mean score	std. deviation
SAT	875	998	203
LSAT	145	150	9

11. Sara and Jerry took a math exam. Sara's percentile score on the exam was 35; Jerry's percentile score on the same test was 70. We know that (choose all the apply)

  a. Sara scored better than 35 of her classmates.

  b. Sara correctly answered half as many items as Jerry did.

  c. They both scored better than average on the math exam.

  d. Jerry correctly answered more items than Sara did.

12. Which of the following is most sensitive to outliers?

  a. interquartile range

  b. standard deviation

  c. median

  d. mode

13. If sample means are examined for samples of size 1, 5, 10, 16 and 50, you will notice that as *n* increases in size, the average of the sample means will estimate the

  a. sample mean

  b. population mean

  c. median

  d. population proportion

  e. sample proportion

14. A card company claims that 80% of all American college students send a card to their mother on Mother's Day. Suppose you plan to gather your own data to test this claim. You select a simple random sample of 400 American college students to determine the proportion of them who send a card to their mother on Mother's Day. Your sample indicates that 70% of the students sampled send a card to their mother on Mother's Day. Does this make you accept or reject the card company's claim? **Justify your answer**.

Appendix B

points total 28 pts

MA 206 Outcomes Assessment Project

Name: Answer Key

Fall 2013

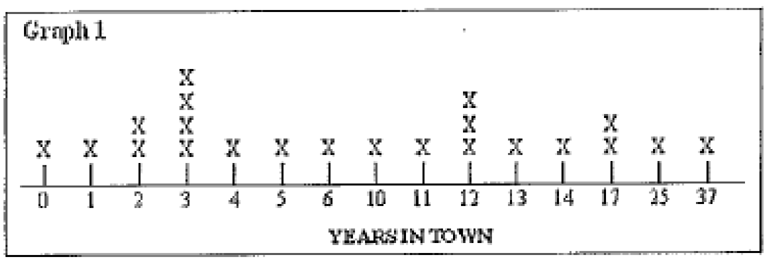
(1 pt) 1. Suppose a particular outcome from a random event has a probability of .02. Which of the following statements represent correct interpretations of this probability?

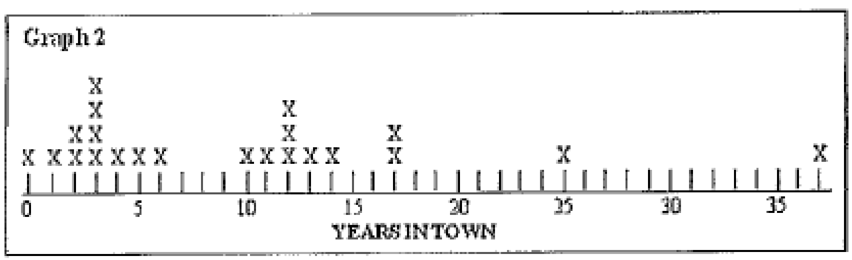
a. The outcome will never happen.
b. The outcome will certainly happen two times out of every 100 trials.
c. The outcome is expected to happen about two times out of every 100 trials.
d. The outcome could happen, or it couldn't, the chances of either result are the same.

(2 pts) 2. A class of students recorded the number of years their families had lived in their town. Here are two graphs that students drew to summarize the data. Which graph gives a more accurate representation of the data? Graph 2

Why? Explain your reasoning in a complete sentence.

Response must mention scale or outlier.





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(2 pts)

Who do you think has the best sampling method?

a. Shannon b. Jake c. Adam d. Claire

Why? Explain your reasoning in a complete sentence.

Response must indicate Shannon uses random sampling.

4. (3 pts) The IQ (intelligence) scores of thirty-three students from the same third grade classroom are presented. One set is for boys and the other set is for girls. Summary statistics (mean, standard deviation, median, and quartiles) are provided for each set of children. Use the stems below to create a back-to-back stem-and-leaf plot so that you can visually compare the IQ scores of the boys with the IQ scores of the girls.

BOYS					GIRLS				
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4 4 3 3	13	
	13	
4	14	
	14	

Write a comparison of the distribution of IQ scores for the boys and girls that includes comparisons of shape, center, and variability. Must mention (1 pt each)

- Boys' mean is higher.
- Girls standard deviation is lower / smaller range.
- Girls distn more symmetric.

5. (1 pt) One of the items on the student survey for an introductory statistics course was "Rate your intelligence on a scale of 1 to 10." The distribution of this variable for the 100 women in the class is presented below. What is the probability of randomly selecting a woman from the class who has an intelligence rating that is LESS than seven (7)?

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8 pts total

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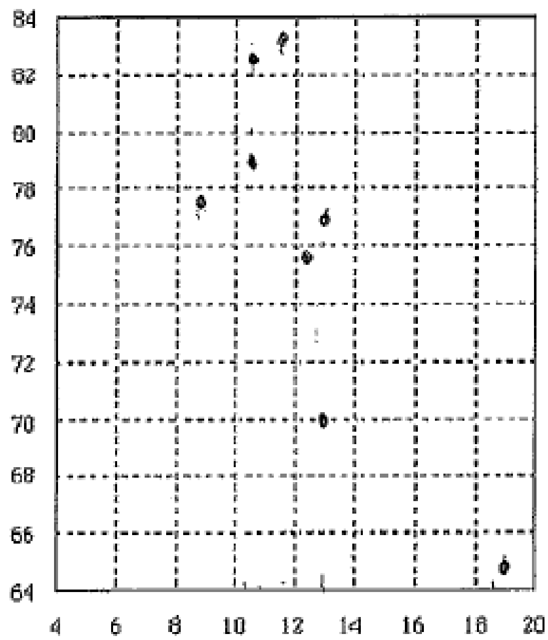

(a) Draw a scatterplot of the two variables using the grid provided. 1 pt

(b) Use data above to get a linear regression equation. (You can either use your calculator or use the points (19, 64.7) and (10.2, 78.8) and the slope-intercept formula $y = mx+b$ to the get the equation.) Write the equation here.

1 pt

$y = 95.55 - 1.58x$ using linreg on calculator or $y = 95.1 - 1.6x$ using two points

(c) Using your regression equation, predict the percentage of adults with HS and above given a poverty rate of 9%. 81.33 or 80.7 Does this prediction make sense? Why or why not?

3 pts

Yes because within range of data

(d) Using your regression equation, predict the percentage of adults with HS and above given a poverty rate of 25%. 56.05 or 55.1 Does this prediction make sense? Why or why not?

3 pts

No because outside range of data (extrapolation).

(For parts c & d, 1 point each for correct numerical value, for correct Yes or No, & for correct reasoning.)

7. a. Give an example of a research study that illustrates the placebo effect.

(2 pts) Response: must indicate one group gets drug & another gets placebo.

b. What is the purpose of the placebo in the context of the research study.

Comparison to a control group and/or eliminate bias

(1 pt) 8. If you flip a fair coin and get heads 5 times in a row, what is the chance of getting tails on the next flip?

a. Greater than 50%

b. 50%

c. Less than 50%

(1 pt) 9. The correlation between two scores on tests was found to be exactly 1. Which of the following would **NOT** be true, regarding the corresponding scatterplot?

a. Every point would lie along a perfect straight line, with no deviations at all.

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10. The distributions of SAT and LSAT scores are both approximately normal and symmetric. Veronica took both tests (at different times) and would like to know on which test her performance was better. Use the data given on each test to decide which score was better, relative to other people who took each test. **Explain your answer.**

(2 pts)

Test	Veronica's score	Mean score	std. deviation
SAT	875	998	203
LSAT	145	150	9

SAT

$z = \frac{875 - 998}{203} \approx -0.61$

LSAT

$z = \frac{145 - 150}{9} \approx -0.56$

She did relatively better on the LSAT.

1 pt

11. Sara and Jerry took a math exam. Sara's percentile score on the exam was 35; Jerry's percentile score on the same test was 70. We know that (choose all the apply)

a. Sara scored better than 35 of her classmates.

b. Sara correctly answered half as many items as Jerry did.

c. They both scored better than average on the math exam.

d. Jerry correctly answered more items than Sara did.

1 pt

12. Which of the following is most sensitive to outliers?

a. interquartile range

b. standard deviation

c. median

d. mode

1 pt

13. If sample means are examined for samples of size 1, 5, 10, 16 and 50, you will notice that as n increases in size, the average of the sample means will estimate the

a. sample mean

b. population mean

c. median

d. population proportion

e. sample proportion

2 pts

14. A card company claims that 80% of all American college students send a card to their mother on Mother's Day. Suppose you plan to gather your own data to test this claim. You select a simple random sample of 400 American college students to determine the proportion of them who send a card to their mother on Mother's Day. Your sample indicates that 70% of the students sampled send a card to their mother on Mother's Day. Does this make you accept or reject the card company's claim? **Justify your answer.**

$\left.\begin{array}{l} H_0: p = 0.8 \\ H_1: p \neq 0.8 \end{array}\right\}$ 1 prop Z test $\rightarrow$ p-value = 5.7 E-7 ≈ 0

$n = 400$ $X = 280$

Reject the null
Accept the alternative that percentage of students who send a card does not equal 80%.

∴ Reject the card company's claim.