Assessing Quantitative Reasoning in Introduction to Probability and Statistics

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About Concordia University, St. Paul

• Christian (Lutheran Church – Missouri Synod)
• Inner-city, St. Paul, MN
• Comprehensive (grounded in the liberal arts)
• NCAA Division II Athletics
  – Volleyball: 7 consecutive national championships
• Tuition Reset (dropped tuition $10,000)
• Head-count: 1300 trad undergrad, 800 cohort degree-completion, 1500 graduate
Traditional Undergraduates

• 35% not Caucasian
  – Small but growing international presence
• 28% first-generation
• 83% Minnesotan
• 30% Lutheran
Quantitative Reasoning

University-wide learning outcomes

• Translates verbal or written assertions into quantitative data
• Reads and analyzes quantitative data
• Interpretation of quantitative data
• Supports conclusion

These are currently assessed in math and physical science courses...130-180 students a year take Introduction to Prob/Stats per year
Collection Instrument

Website: elumen.info
Scale

• 0 – Did not attempt activity or little effort
• 1 – Beginning
• 2 – Developing
• 3 – Accomplished
• 4 – Exemplary
• NA – Default; Faculty didn’t enter data
  – Working on faculty communication to minimize number of NA values in the data set
Translates verbal or written assertions into quantitative data

<table>
<thead>
<tr>
<th>Beginning</th>
<th>Developing</th>
<th>Accomplished</th>
<th>Exemplary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student develops mathematical expressions and/or operational definitions from verbal or written assertions with significant errors.</td>
<td>Student develops mathematical expressions and/or operational definitions from verbal or written assertions with few errors.</td>
<td>Student develops appropriate mathematical expressions and/or operational definitions from verbal or written assertions.</td>
<td>Student develops appropriate mathematical expressions and/or operational definitions from verbal or written assertions with clearly defined variables and/or units.</td>
</tr>
</tbody>
</table>
Translates verbal or written assertions into quantitative data

Find the probability that a committee of four women and two men are randomly selected from six women and five men. Carefully explain each step of the process and use words.

1 - some attempt at setting up the expression
2 - correct identification as a combination or probability problem
3 - equation correctly identified, some possible execution errors
4 - expression correctly set up, solved correctly, with each step carefully explained
## Reads and analyzes quantitative data

<table>
<thead>
<tr>
<th>Beginning</th>
<th>Developing</th>
<th>Accomplished</th>
<th>Exemplary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student exhibits ability to differentiate between qualitative and quantitative data.</td>
<td>Student either chooses or properly applies a method of quantitative analysis</td>
<td>Student chooses and properly applies a method of quantitative analysis</td>
<td>Student uses or compares more than one method of quantitative analysis.</td>
</tr>
</tbody>
</table>
Reads and analyzes quantitative data

The average local cell phone call length was reported to be 2.27 minutes with standard deviation of .75 minute. A random sample of 40 phone calls showed an average of 2.48 minutes in length. At $\alpha = 0.05$, is there enough evidence to say a difference was found?

a) Do all five steps of the hypothesis test.

b) Find the 95% confidence interval for this problem.

c) Comment on the relationship between parts a and b. Explain thoroughly.

1 - attempts an answer
2 - answers a) or b) correctly
3 - answers a) and b) correctly
4 - answers a), b) and c) correctly
## Interpretation of quantitative data

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beginning</strong></td>
<td>Student interprets the quantitative data with significant errors</td>
</tr>
<tr>
<td><strong>Developing</strong></td>
<td>Student interprets the quantitative data with few errors</td>
</tr>
<tr>
<td><strong>Accomplished</strong></td>
<td>Student accurately interprets the quantitative data with no errors.</td>
</tr>
<tr>
<td><strong>Exemplary</strong></td>
<td>Student accurately interprets the quantitative data recognizing the limitations of the methodology used</td>
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</tbody>
</table>
Interpretation of quantitative data

• The National Football League Commissioner wants to know if the NFC quarterbacks threw fewer touchdowns than AFC quarterbacks so far this season. Given $\alpha = 0.05$, use the sample data and standard deviations below to determine if this is true. (Do all five steps)

NFC: 14, 21, 16, 11, 15, 14, 28 (standard deviation is 5.7)
AFC: 24, 12, 13, 18, 19, 23 (standard deviation is 5.0)

1 - some attempt at setting up the five steps with significant errors
2 - some steps correctly identified and executed
3 - all steps correctly identified, some possible execution errors or lack of result summary
4 - all 5 steps correctly identified and executed with thorough summary of the results
## Supports conclusion

<table>
<thead>
<tr>
<th>Beginning</th>
<th>Developing</th>
<th>Accomplished</th>
<th>Exemplary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student uses no quantitative data to support their conclusion</td>
<td>Student incorrectly uses quantitative data to support conclusion</td>
<td>Student accurately uses quantitative data to support conclusions</td>
<td>Student accurately uses quantitative data to support conclusions and recognizes extensions of the problem and/or conclusion</td>
</tr>
</tbody>
</table>
Supports Conclusion

A teacher gave a math pretest and post-test. The table shows the number each student got right for each test. At $\alpha = 0.10$, did the students score significantly better on the post-test? From the given information, complete the remaining steps with complete justification of the decision and appropriate summary. (We provide hypotheses, test value, and critical value.)

1 - some attempt at solving the exercise, but no correct answers
2 - steps 4 or 5 correctly identified
3 - steps 4 and 5 correctly identified but decision or summary incomplete
4 - both steps 4 and 5 correctly identified and executed
<table>
<thead>
<tr>
<th>Task</th>
<th>Spring 2013</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Fall 2012</th>
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</thead>
<tbody>
<tr>
<td>Translates verbal or written assertions into quantitative data</td>
<td>1.5% 0.0% 10.8% 26.2% 32.3% 30.8% 100% (65)</td>
<td>2.6% 0.0% 6.7% 13.3% 57.3% 22.7% 100% (75)</td>
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<tr>
<td>Reads and analyzes quantitative data</td>
<td>1.5% 0.0% 12.3% 36.9% 30.8% 20.0% 100% (65)</td>
<td>2.6% 0.0% 1.3% 22.7% 60.0% 16.0% 100% (75)</td>
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<tr>
<td>Interpretation of quantitative data</td>
<td>1.5% 0.0% 12.3% 23.1% 41.5% 23.1% 100% (65)</td>
<td>2.6% 1.3% 9.3% 33.3% 52.0% 4.0% 100% (75)</td>
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<td>Supports conclusion</td>
<td>1.5% 0.0% 18.5% 24.6% 38.5% 18.5% 100% (65)</td>
<td>2.6% 1.3% 8.0% 52.0% 25.3% 13.3% 100% (75)</td>
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<td>Term subtotals:</td>
<td>2.1% 0.7% 12.9% 39.3% 31.4% 15.7% 100% (140)</td>
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