Expanding our View and Definition of Quantitative Reasoning

Dr. Judith E Canner
Quantitative Reasoning Assessment Coordinator
Associate Professor of Statistics
California State University, Monterey Bay
Outline

– Expanded View and Definition of Quantitative Reasoning
– Impact of Expanded View on Campus-Wide Assessment
– Impact of Expanded View on Closing-the-Loop
Expanded View and Definition of Quantitative Reasoning
Why do we need an expanded view of Quantitative Reasoning?

- Original AAC&U Value Rubric very “math centric”
- Invite programs into understanding their role in QR
- QR goes beyond mathematical operations
  - Production
  - Consumption
  - Use
Quantitative Reasoning
Definition

AAC&U

- A "habit of mind," competency, and comfort in working with numerical data... the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations.
Quantitative Reasoning

**Definition**

AAC&U

- A "habit of mind," competency, and comfort in working with numerical data... the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations.

**Expanded Definition**

- A "habit of mind," competency and comfort in working with quantitative data, results, or forms and the ability to reason or solve problems in a wide variety of authentic contexts and everyday life situations.
## Quantitative Forms Expanded Definition

<table>
<thead>
<tr>
<th>Mathematical Forms</th>
<th>Additional Forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Graphs</td>
<td>– Timelines</td>
</tr>
<tr>
<td>– Formulas</td>
<td>– Musical Meters</td>
</tr>
<tr>
<td>– Diagrams</td>
<td>– Scale Drawings</td>
</tr>
<tr>
<td>– Tables</td>
<td>– Comparatives/Ratios</td>
</tr>
<tr>
<td>– Systems of Equations</td>
<td>– Structure Design</td>
</tr>
</tbody>
</table>
Quantitative Reasoning Expanded Definition

– Quantitative Reasoning is sophisticated reasoning even when using simple quantitative methods/information/forms, not simple reasoning using sophisticated quantitative methods/information/forms.
– Adapted from Eric Gaze (Bowdoin College)
Quantitative Reasoning Categories

– Calculation
– Representation
– Interpretation
– Analysis
– Communication
– Assumptions
Quantitative Reasoning Categories - Expanded

- Calculation
- Representation
- Interpretation
- Analysis
- Communication
- Assumptions
- Reasonableness
## Calculation

### Expanded Definition

<table>
<thead>
<tr>
<th>Expanded</th>
<th>Original</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Ability to perform quantitative procedures necessary to solve a problem, or to convert data into information or results.</td>
<td>– None</td>
</tr>
<tr>
<td>Representation</td>
<td>Expanded Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td><strong>Expanded</strong></td>
</tr>
<tr>
<td></td>
<td>– Ability to convert, organize, summarize, or present</td>
</tr>
<tr>
<td></td>
<td>relevant information into various quantitative forms.</td>
</tr>
</tbody>
</table>
Interpretation
Expanded Definition

Expanded

- Ability to identify and describe information presented in a quantitative form.
- Remember/Understand

Original

- Ability to explain information presented in mathematical forms
Analysis/Application Expanded Definition

Expanded

– Ability to make judgments and predictions and to draw appropriate specific conclusions or inferences based on quantitative information or forms, while recognizing the limits of this analysis
– Apply/Analyze/Evaluate

Original

– Ability to make judgments and draw appropriate conclusions based on the quantitative analysis of data, while recognizing the limits of this analysis
Communication
Expanded Definition

**Expanded**

– Ability to express quantitative evidence in support or refutation of the argument or purpose of the work.
– Synthesize/Create

**Original**

– Expressing quantitative evidence in support of the argument or purpose of the work
### Assumptions

#### Expanded Definition

<table>
<thead>
<tr>
<th>Expanded</th>
<th>Original</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Ability to use and evaluate important</td>
<td>– Ability to make and evaluate important assumptions in estimation,</td>
</tr>
<tr>
<td>assumptions, theory, or bias in creation,</td>
<td>modeling, and data analysis</td>
</tr>
<tr>
<td>development, or analysis of quantitative</td>
<td></td>
</tr>
<tr>
<td>forms.</td>
<td></td>
</tr>
</tbody>
</table>
Reasonableness
Expanded Definition

– Ability to evaluate and justify whether a provided solution or inference makes sense in the context of the problem.
– Often exhibited in situations where a student evaluates another person’s solution or inference based on quantitative information

<table>
<thead>
<tr>
<th>Advanced</th>
<th>Proficient</th>
<th>Developing</th>
<th>Beginner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognizes solution or inference as unreasonable or reasonable, and can justify the assessment of reasonableness. If the solution or inference is unreasonable, determines where error occurred and corrects error if possible.</td>
<td>Recognizes solution or inference as unreasonable or reasonable, and can justify the assessment of reasonableness.</td>
<td>Recognizes solution or inference as unreasonable or reasonable, but cannot justify the assessment of reasonableness.</td>
<td>Incorrectly identifies a solution or inference as unreasonable or reasonable.</td>
</tr>
</tbody>
</table>
Reasonableness Example

- “Over the span of more than a decade, 2,151 whites died by being shot by police compared to 1,130 blacks, therefore there is not a racial disparity in police shootings against minorities” - 2014 Talk Show Host (paraphrased)
Reasonableness Example

- “Over the span of more than a decade, 2,151 whites died by being shot by police compared to 1,130 blacks, therefore there is not a racial disparity in police shootings against minorities”

- PolitiFact rated "half true" because whites make up 63% of the population, while blacks make up just 12%

- Movement into Assumptions
  - Homicide and felony rates by race
  - Incomplete and biased sources of data
Impact of Expanded View on Campus-Wide Assessment
Assessment Results
Spring 2015

- Artifact Assessment
  - 219 artifacts assessed
  - 32 courses (45 sections)
- Online Assessment
  - 411 students assessed
- Additional Information Collected
  - Major Learning Outcome Review
  - National Survey of Student Engagement (NSSE)
  - Faculty Survey
  - Assignment Review
Assessment Results
Spring 2015

- **Artifact Assessment**
  - 219 artifacts assessed
  - 32 courses (45 sections)
- **Online Assessment**
  - 411 students assessed
- **Additional Information Collected**
  - Major Learning Outcome Review
  - National Survey of Student Engagement (NSSE)
  - Faculty Survey
  - Assignment Review
Assessment Results
Faculty and Student Perspective

– Students and Faculty feel Quantitative Reasoning education is not sufficient
  – 20% of students reported never using Quantitative Reasoning in their courses (NSSE)
  – 89% of faculty responding to survey indicated dissatisfaction with the current state of Quantitative Reasoning at CSUMB (Fall 2014 Survey).
Assessment Results
Variety in Assignment Types

- **College of Science**
  Science and Environmental Policy (BIO, ENSTU, ENVS, MSCI) (10 courses)
  Mathematics and Statistics (MATH, STAT) (7 courses)

- **College of Business**
  Business Administration (BUS) (4 courses)

- **College of Health Sciences and Human Services**
  Kinesiology (KIN) (1 course)
  Health, Human Services, and Public Policy (CHHS) (1 course)

- **College of Education**
  Liberal Studies (HDEV, LING) (2 courses)

- **College of Arts, Humanities, and Social Sciences**
  Psychology (PSY) (3)
  Social, Behavioral, and Global Studies (SBS) (2 courses)
  Visual and Public Arts (VPA) (1 course)
  World Languages and Cultures (JPN, SPAN) (2 courses)
## Assessment Results

### Assignment Design

<table>
<thead>
<tr>
<th>Category</th>
<th>Proportion of Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation</td>
<td>92%</td>
</tr>
<tr>
<td>Representation</td>
<td>84%</td>
</tr>
<tr>
<td>Interpretation</td>
<td>97%</td>
</tr>
<tr>
<td>Analysis</td>
<td>95%</td>
</tr>
<tr>
<td>Communication</td>
<td>68%</td>
</tr>
<tr>
<td>Assumptions</td>
<td>38%</td>
</tr>
<tr>
<td>Reasonableness</td>
<td>35%</td>
</tr>
</tbody>
</table>
### Assessment Results

#### Assignment Design

<table>
<thead>
<tr>
<th>Category</th>
<th>Proportion of Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation</td>
<td>92%</td>
</tr>
<tr>
<td>Representation</td>
<td>84%</td>
</tr>
<tr>
<td>Interpretation</td>
<td>97%</td>
</tr>
<tr>
<td>Analysis</td>
<td>95%</td>
</tr>
<tr>
<td>Communication</td>
<td>68%</td>
</tr>
<tr>
<td>Assumptions</td>
<td>38%</td>
</tr>
<tr>
<td>Reasonableness</td>
<td>35%</td>
</tr>
</tbody>
</table>
Assessment Results
Artifact Assessment

Proficiency of Student in Quantitative Reasoning

Proportion of Seniors at Highest Level at Proficiency

Category of Quantitative Reasoning

- Interpretation: 0.62
- Representation: 0.55
- Analysis: 0.54
- Assumptions: 0.33
- Communication: 0.5
- Reasonableness: 0.41
- Calculation: 0.59
Assessment Results
Artifact Assessment

Proficiency of Seniors at Highest Level of Quantitative Reasoning in their Major

- Interpretation: 0.71
- Representation: 0.66
- Analysis: 0.66
- Assumptions: 0.5
- Communication: 0.56
- Reasonableness: 0.31
- Calculation: 0.63
Impact of Expanded View on Closing-the-Loop
Closing-the-Loop
Reinforce QR Across the Curriculum

- Assignment design informs student performance
  - Assignment Design Workshops
  - Integrated Rubrics
- Consultation with Programs and GE
  - Major Learning Outcome
  - Area B4 GE and beyond
  - Core Courses
  - Capstones
- Next Assessment: Spring 2017
Closing-the-Loop Teaching Analysis Workshop

- Teaching Students to Evaluate Quantitative Evidence (w/o teaching them math)
  - Why teach with quantitative information
  - How to teach with quantitative information
  - How to engage students with quantitative information
- Emphasis on
  - Reasonableness/Assumptions
    - Hierarchy of Evidence
    - Questioning Evidence
  - Interpretation/Analysis/Communication
    - Synthesizing Evidence
Study Links Polluted Air in China to 1.6 Million Deaths a Year

By DAN LEVIN    AUG. 13, 2015

BEIJING — Outdoor air pollution contributes to the deaths of an estimated 1.6 million people in China every year, or about 4,400 people a day, according to a newly released scientific paper.
Summary

- Quantitative Reasoning goes beyond mathematics
- Expanded view invites the whole campus to take ownership of QR
- Assignment design increases student achievement
- Next Steps: Inform teaching based on the expanded view of QR