QUANTITATIVE REASONING IN FIELDS OTHER THAN MATHEMATICS

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An Expanded View of Quantitative Reasoning

• AAC&U Definition
  A “habit of mind,” competency and comfort in working with numerical data and the ability to reason or solve problems in a wide variety of authentic contexts and everyday life situations.

• CSUMB 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.

Presentation by Dr. Judith Canner on expanded view of QR: https://www.youtube.com/watch?v=nF97IY6FEAg
Dissecting the numbers

- Ask "What if...",
- Interpret the magnitude of a quantity,
- Check the accuracy of stated facts or conduct a little research on the topic,
- Discuss how quantities were measured and who did the measuring,
- Perform a quick calculation or engage in mental estimation to check the author's claim(s),
- Convert an absolute change into a relative change or vice versa,
- Compare numerical information in the article with that presented in graphical format, or
- Become familiar with language used to represent and compare quantities.
Quick and Dirty Guide

• Is the sample biased?
• Is the sample size small?
• Are the chosen statistics inappropriate?
• Are the results practically meaningful?
• Are the graphics misleading?
• Do the results actually support the claims?
• Is it truly a causative effect?

Adapted from “How to Lie With Statistics”
Example

Amid the debate about inequality, there’s an underplayed point about the current economy: average workers have not only been earning less than those at the top. Many have been earning less, *full stop.* Seen over a period of three or four decades, the trend is striking. Take a look at the chart below of the decline in real earnings for U.S. men in three age groups — 25-34, 35-44, and 45-54.

**The Great Retrenchment**

[Chart showing the decline in median income for U.S. men by age, in 2012 dollars. Source: U.S. Census Bureau]
The Great Retrenchment

Median Income for U.S. Men by Age, in 2012 Dollars. Source: U.S. Census Bureau
Lower the y-axis

The author’s original two datapoint chart, adjusted to show the whole y-axis
Include all the years from 1972-2011 and 2012 to get more resolution. Here's what we get:
Lower the y-axis

*amplify changes.* Let’s see what happens when we make the y-axis go down to zero with the same data as in the previous example:
Change the boundary dates
Two data points

What two datapoints tell us happened to incomes between 1947 and 2012
## Goals and outcomes for QR in student writing


<table>
<thead>
<tr>
<th>Goals</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Thinks quantitatively</td>
<td>1. States questions and issues under consideration in numerical terms.</td>
</tr>
<tr>
<td></td>
<td>2. Identifies appropriate quantitative or numerical evidence to address questions and issues.</td>
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<td></td>
<td>3. Investigates questions by selecting appropriate quantitative or numerical methods.</td>
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<tr>
<td>II. Implements competently</td>
<td>1. Generates, collects, or accesses appropriate data.</td>
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<td></td>
<td>2. Uses quantitative methods correctly.</td>
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<td></td>
<td>3. Focuses analysis appropriately on relevant data</td>
</tr>
<tr>
<td>III. Interprets and evaluates thoughtfully</td>
<td>1. Interprets results to address questions and issues under consideration</td>
</tr>
<tr>
<td></td>
<td>2. Assesses the limitations of the methods employed, if appropriate to the task or assignment</td>
</tr>
<tr>
<td>IV. Communicates effectively</td>
<td>1. Presents and/or reports quantitative data appropriately</td>
</tr>
</tbody>
</table>
Making meaning from infographics

“On the question of, if you ever been discriminated here at CSUMB, as you can see when focusing on the race/ethnicity bar graph, African Americans being the green bar 37% and pink being Asian at 29%, white being the blue graph 16% and last but not least Latina being purple at 21%.”
Interpreting infographics

Have you experienced bias/harassment/discrimination at CSUMB?

- Citizenship status: 9% (Asian PI), 2% (Afr Am/Black), 5% (Latino/a), 2% (White)
- Sexual orientation: 7% (Asian PI), 6% (Afr Am/Black), 7% (Latino/a), 6% (White)
- Disability: 7% (Asian PI), 7% (Afr Am/Black), 8% (Latino/a), 6% (White)
- Gender: 21% (Asian PI), 17% (Afr Am/Black), 18% (Latino/a), 23% (White)
- Race/ethnicity: 29% (Asian PI), 37% (Afr Am/Black), 21% (Latino/a), 16% (White)
Infographics—Numbers without context

“Figure 1 shows a high amount of homeless in Santa Cruz county divided into family and single person’s.”
Reasonableness

• “In the California health interview survey, conducted in 2009, 57% of Californians residence are obese. This shows that most people are overweight, according to the Body Mass Index (BMI).”
Program-level QR development

Environmental Studies, B.A.

Observations from program-level capstone assessment (Spring ‘15 & ‘Fall 15)

- Majority of students not demonstrating degree-level critical thinking (as defined by the AAC&U Critical Thinking VALUE Rubric)
- Majority of students not using quantitative reasoning when presenting background, results, or the project evaluation

Initial response

- Environmental Studies capstone instructor (Dr. Hester Parker) contacts QR Assessment Coordinator (Dr. Judith Canner)
Response ~ spring '16

Environmental Studies Capstone (2-semester sequence)

2nd semester course

- Presentation by QR Assessment Coordinator on “The Process of Statistics”
- Use data set from an earlier (required) 200-level course to “re-teach” students how to create spreadsheets and produce tables and figures from own data

Recommendations for fall 16

- Move presentation to 1st-semester course and make more interactive
- Continue use of spreadsheet guide
- Provide more individual support
Response ~ fall ‘16

1st semester capstone
- Guest faculty member from Math & Statistics (Dr. Steven Kim) facilitated a more interactive workshop

Outline

- This workshop will be presented in the following order.
  1. Formulating an answerable research question.
  2. Sampling methods
  3. Variable type
  4. Recording data (spreadsheet)
  5. Special topics
     - Evaluating Efficacy
     - Response, explanatory and confounding variables
     - Repeated measurements
  6. Importance of communication with statisticians before data collection
Response ~ fall ‘16

2nd semester capstone
• Three guest faculty members from Math & Statistics and one from Environmental Studies attend a class session to work with student subgroups on integrating QR into their projects
• Students prep for session (below)
• Students have individual consultations with those faculty later in semester

In addition, prepare answers to the following questions on your own (for when you meet with statistics consultants later in semester) and to recap what you learned from your discussions with Tori and Alana last week (i.e. are you better able to answer any of the following questions after having spoken with them?):

For this week, one group (BLM Habitat Restoration project) will meet with the statistics “consultants” in Dr. Kim’s class from 1-1:50pm in BIT 222. Other students/groups will be able to go to his class on other dates during the semester (except March 2).

What is the population of interest?
What is the sample you will have access to (or be collecting)?
Does the sample truly represent the population of interest? If the answer is no, what population does the sample represent and how does that limit the scope of your research questions?
What are your research questions?
What information do you plan to collect to assess each question?
How will that information help you to answer their research questions?
Response ~ fall ‘16

Conduct program assessment project of QR in a (required) 200-level Environmental Studies course.

<table>
<thead>
<tr>
<th>Interpretation</th>
<th>Representation</th>
<th>Analysis</th>
<th>Assumptions</th>
<th>Communication</th>
<th>Reasonableness</th>
<th>Calculation</th>
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<tbody>
<tr>
<td># scores grade level (2+)</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>12</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>% scores grade level (2+)</td>
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<td>47%</td>
<td>47%</td>
<td>35%</td>
<td>50%</td>
<td>59%</td>
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<tr>
<td># scores proficient (3+)</td>
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<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>% scores proficient (3+)</td>
<td>9%</td>
<td>9%</td>
<td>6%</td>
<td>3%</td>
<td>9%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Resulted in changes to the 200-level course to provide students with QR knowledge and skills needed for capstone.
Response ~ spring ‘17

1st semester capstone
• Capstone instructor gives interactive presentation (instead of Math & Statistics guest faculty)

2nd semester capstone
• Math & Statistics and Env. Studies guest faculty members attend a class session (as in fall ‘16)
• Environmental Studies students do individual follow-up consultations with Math & Statistics students (enrolled in a class of one of the guest faculty members)
Results

The results of this project showed that six months after initial restoration there was a 30% survivability rate, and after nine months the rate was at 26%. This data shows that the plants are not thriving in the quadrat. This could be because of the drought California has been experiencing during the year, the 25 degree slope of the study plot, species specific factors such as prefered seasonal growth, or perhaps that the plants were planted by students and not professionals. Of the six species planted in the plot, sticky monkey flower is surviving at the greatest rate. It was interesting to see that after nine months, there has been a great increase in non-native grasses in the area. This is an indication that the restoration may not be acting as quickly as needed for the site to return to its original native state. However, these grasses are seasonal and should not have a large effect on the longevity of the natives planted in March of 2014. With rain coming to the area in late November - early December, it is possible that more natives will begin to emerge in the quadrat if seeds have spread. Since only two entries have been made in the citizen science book at the site and only nine months have passed since the restoration occurred, it will take time to see the full results of this project.

Project evaluation

This project was limited by the absence of knowing exactly how many of each species were
Results:

For our project we sampled 15 restoration sites between 3 different landscapes: 5 chaparral sites, 5 oak woodland sites, and 5 grassland sites. On arrival at the sites we made a visual assessment of what portions best represented the area as shown in Figure 1. With the x-

Figure 1: Proportion of Bare Ground to Plant/Litter Coverage

Figure 3: Student individual score averages for El Sausal Middle School. 1 being the lowest score and 4 being the highest score. The pre-survey average is 2.5 and the post-survey average increased to 3.26.

Figure 4: Student individual score averages for Washington Middle School and El Sausal Middle School combined. 1 being the lowest score and 4 being the highest score. The pre-survey average is 2.55 and the post-survey average increased to 3.21.
ENSTU 350: Research Methods in Environmental Studies

New course for ENSTU Majors
Fall 2017!

New and innovative methods for community engagement
Ways of designing and assessing community-based capstone projects
Participatory methods such as Photovoice, City as Play, and Community Mapping

Learn applied skills for working effectively with communities.
Next Steps

• Assess QR in spring 2017 capstones
• Share results with Environmental Studies faculty
• Develop criteria and minimum standards for degree-level proficiency in QR (in capstone)
• Revise capstone requirement to require minimum level of QR
• Revise capstone project guidelines and grading rubric to make QR expectations explicit
Intellectual skills integrated assignment guides and rubrics

- Created by faculty after 1st institution-level assessment of the core competencies
- Presentation on QR rubric components (by Dr. Judith Canner): [https://www.youtube.com/watch?v=nF97IY6FEAg](https://www.youtube.com/watch?v=nF97IY6FEAg)

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**Quantitative Reasoning, Critical Thinking, and Information Literacy Assignment Guide**

This guide is a tool teachers can use to critically examine and improve their assignment guidelines for the purpose of helping student produce better work. There is no expectation that an assignment explicitly address all questions posed in the guide. Rather, each question poses questions to help teachers make their own decisions about what kinds of prompts to include -- or not to include -- in an assignment. There may be several different types of assignments that assess quantitative reasoning (QR), including the following:

- **Exam:** Questions on exam may be written to explicitly assess each category of quantitative reasoning or more than one category of quantitative reasoning. The original QR rubric categories may be sufficient to assess the proficiency of students on exam style assignments.

- **Creation:** Students must analyze raw data or develop original quantitative forms. In such assignments Calculation and Representation may feature as a large part of the assignment that does not end up in the final product (e.g., papers or presentations). In such cases, alternative methods of demonstration of these categories may be considered for submission in addition to the final product.

- **Synthesis:** Students must synthesize evidence collected by others (quantitative forms of information) from a variety of sources in support of an argument or purpose of work. In such cases, Calculation and Representation may not feature in the assignment prompts (though students may be asked to assess others’ Calculations and Representations through the lens of the other categories of QR).

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**Quantitative Reasoning, Critical Thinking & Information Literacy Integrated Rubric**

<table>
<thead>
<tr>
<th>Category</th>
<th>4 - Advanced</th>
<th>3 - Proficient</th>
<th>2 - Developing</th>
<th>1 - Beginner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue/problem</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Support</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Interpretation</td>
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</tbody>
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Assignments

Kinds of assignments to assess QR

• Exam
• Creation
• Synthesis
Integrated assignment guide

• Includes criteria from QR, CT, IL, and WC
• Turns rubric descriptors into questions to help analyze (or design) assignments and teaching.