CAA University Learning Goals Committee

Quantitative Reasoning

Handouts Related to Quantitative Reasoning

Contents

Learning Goals - Quantitative Reasoning Overview

EIU graduates produce, analyze, interpret, and evaluate quantitative material by:

- Performing basic calculations and measurements.
- Applying quantitative methods and using the resulting evidence to solve problems.
- Reading, interpreting, and constructing tables, graphs, charts, and other representations of quantitative material.
- Critically evaluating quantitative methodologies and data.
- Constructing cogent arguments utilizing quantitative material.
- Using appropriate technology to collect, analyze, and produce quantitative materials.

Association of Colleges & Universities – Definition of Quantitative Literacy

Quantitative Literacy (QL) – also known as Numeracy or Quantitative Reasoning (QR) – is a "habit of mind," competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence and they can clearly communicate those arguments in a variety of f or mats (using words, tables, graphs, mathematical equations, etc., as appropriate).

Quantitative Reasoning (QR) has been described as a "habit of mind," a competency and comfort in working with numerical data. Individuals with strong QR skills:

- Can reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations
- Can understand and create sophisticated arguments supported by quantitative evidence
- Can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, as appropriate)

The quantitative reasoning (QR) demands imposed by today's society are enormous and growing, as documented in numerous sources. One of the important characteristics of quantitative reasoning is that it must be situated in the contexts and disciplines where it is used. It is not necessarily a discipline, but a way of thinking that influences what, how, and why students learn what they do.

Accordingly, a quantitatively literate college graduate should be able to (Sons et al, 1996):

- Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
- Represent mathematical information symbolically, visually, numerically, and verbally.
- Use arithmetical, algebraic, geometric and statistical methods to solve problems.
- Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.
- Recognize that mathematical and statistical methods have limits.

10 Foundational Quantitative Reasoning Questions

Neil Lutsky, Psychology

I. What do the numbers show?

a. What do the numbers mean?
b. Where are the numbers?
    i. Is there numerical evidence to support a claim?
    ii. What were the exact figures?
    iii. How can seeking and analyzing numbers illuminate important phenomena?
c. How plausible is a possibility in light of back of the envelope calculations?

II. How representative is that?

a. What's the central tendency?
    i. "For instance is no proof."
    ii. Mean, Mode, and Median.
    iii. Interrogating averages:
b. Are there extreme scores?
    i. Are there meaningful subgroups?
    ii. Who's in the denominator?
    iii. What's the variability (standard deviation)?
c. What are the odds of that? What's the base rate?

III. Compared to what?

a. What's the implicit or explicit frame of reference?
b. What's the unit of measurement?
c. Per what?
d. What's the order of magnitude?
e. Interrogating a graph:
    i. What's the Y-axis? Is it zero-based?
    ii. Does it K.I.S.S., or is it filled with ChartJunk?

IV. Is the outcome statistically significant?

a. Is the outcome unlikely to have come about by chance?
    i. "Chance is lumpy."
    ii. Criterion of sufficient rarity due to chance: $p < .05$
b. What does statistical significance mean, and what doesn't it mean?

V. What's the effect size?

a. How can we take the measure of how substantial an outcome is?
b. How large is the mean difference? How large is the association?
c. Standardized mean difference (d): $d = (\mu 1 - \mu 2)/\sigma$

VI. Are the results those of a single study or of a literature?

a. What's the source of the numbers: PFA, peer-reviewed, or what?
b. Who is sponsoring the research?
c. How can we take the measure of what a literature shows?
d. The importance of meta-analysis in the contemporary world of QR.

VII. What's the research design (correlational or experimental)?

a. Design matters: Experimental vs. correlational design.
b. How well does the design support a causal claim?
c. Experimental Design:
    i. Randomized Controlled Trials (RCT): Research trials in which participants are randomly assigned to the conditions of the study.
    ii. Double blind trials: RCTs in which neither the researcher nor the patient know the treatment condition.
d. Correlational Design: Measuring existing variation and evaluating co-occurrences, possibly controlling for other variables.
    i. Interrogating associations (correlations):
    ii. Are there extreme pairs of scores (outliers)?
    iii. Are there meaningful subgroups?
    iv. Is the range of scores in a variable restricted?
    v. Is the relationship non-linear?

VIII. How was the variable operationalized?

a. What meaning and degree of precision does the measurement procedure justify?
b. What elements and procedures result in the assignment of a score to a variable?
c. What exactly was asked?
d. What's the scale of measurement?
e. How might we know if the measurement procedure is a good one?
    i. Reliability = Repeated applications of procedure result in consistent scores.
    ii. Validity = Evidence supports the use to which the measure is being put.
f. Is the measure being manipulated or "gamed"? The iatrogenic effects of measurement.

IX. Who's in the measurement sample?

a. What domain is being evaluated? Who's in? Who's not?
b. Is the sample from that domain representative, meaningful, and/or sufficient?
c. Is the sample random?
d. Are two or more samples that are being compared equivalent?

X. Controlling for what?

a. What other variables might be influencing the findings?
b. Were these assessed or otherwise controlled for in the research design?
c. What don't we know, and how can we acknowledge uncertainties?

Teaching

Best Practices in Quantitative Reasoning

Source: Numeracy Infusion Course in Higher Education

In *Powerful Learning: What we Know about Teaching for Understanding*, Darling-Hammond (2008) argues that meaningful learning is accomplished through a number of key approaches including: "(1) creating ambitious and meaningful tasks, (2) engaging students in active learning, (3) drawing connections to students, (4) scaffolding the learning process, (5) assessing student learning continuously, (6) providing clear standards and constant feedback, and (7) encouraging strategic and metacognitive thinking." Likewise, successful instruction in QR requires progressive pedagogy: "connecting content to real-life situations, lighter coverage of topics, an emphasis on understanding concepts rather than facts, integrating content across disciplinary boundaries" (Cuban, 2001).

1. **Real World Applications & Active Learning, including Discovery**
   Studies show that most students learn more when engaged in active learning. Don't simply show them how to work with numbers; let them get involved.
   - Use real-data, or data simulations
   - Role play in a case-study
   - Involve students in the data collection process
   - Request that students interpret tables and charts rather than providing the information for them
   - Focus on quantitative reasoning (e.g., using numbers in context) rather than simple computation and math skills
   - Ask students to postulate potential explanations for published findings (for e.g. from newspapers)

2. **Pairing QR instruction with Writing, Storytelling & Critical Reading**
   To become fully quantitatively literate, students must be able to communicate their quantitative arguments, first by analyzing the quantitative analyses of others, and then communicate their own.
   - Provide quantitative writing assignments that require students to grapple with numbers in a real world context, to describe observations using numbers, and to use the numbers in their own analyses and arguments. In addition, these types of assignments can ask students to draw conclusions based on numerical or other quantitative evidence, which is either supplied or which the students must develop.
   - Use backwards-design by focusing on what needs to happen first (for e.g., class activities, earlier assignments etc.) to arm students with the tools to complete the assignment.

- Instead of using procedural, algorithmic questions, use questions that require more involved reasoning and critical thinking skills.

3. **Using Technology, including Computers**
   The use of technology can actively engage students in QR work, promote logical thinking and help students master QR skills that are central to the research process.
   - Numerous software packages are freely available to students, including discipline-specific and survey software. Encourage students to get a copy of the software for use at home for assignments, or use on-campus computer labs.
   - Spreadsheets allow students to 'get their hands dirty' by working with real-world data. Allow students to create 'what if' analyses from concrete examples.

4. **Collaborative Instruction & Group Work**
   Interdisciplinary and collaborative approaches, including group work, are effective strategies for promoting mathematics and QR education.
   - Use groups for QR assignments, incorporating research, spreadsheet manipulation, statistical analysis and presentation. Whether the assignment is completed as a team or individual final projects, teamwork can reduce pressure on instructors to provide skill remediation.
   - Use small-group learning exercises to read and evaluate data.

5. **Pedagogy that is sensitive to cultures & learning style**
   Students' perceptions of quantitative reasoning, their academic, and their development as quantitatively literate citizens all depend on our ability to engage all our students, not just our "math whizzes" and high achievers.
   - Some strategies for overcoming inequalities include working cooperatively, promoting discussion and idea sharing, and using hands-on materials.
   - Use visualization, icons, symbols, and graphic organizers to represent learning
   - Teach students how to collect, record, and condense quantitative information.
   - Collaborate with reference librarians to find sources of relevant quantitative information that are also narrow in scope

6. **Scaffolding the Learning Process**
   Incorporating QR assignments are complex because they ask students to combine math skills within the context of a problem and craft an argument around it. Scaffolding early assignments provides students "with enough help to complete a task, and then gradually decreases the help as the student becomes able to work independently." (Killen, 2006, 7)
   - Give students rich feedback on the data they propose to use
   - Provide ample opportunities to master the material, particularly if not successful the first time around

Guide to Quantitative Writing

Source: Carleton College.

Quantitative writing (QW) requires students to grapple with numbers in a real world context, to describe observations using numbers, and to use the numbers in their own analyses and arguments. Good quantitative writing assignments ask students to do more than compute an answer. In addition they ask students to draw conclusions based on numerical or other quantitative evidence, which is either supplied or which the students must develop.

Characteristics of Quantitative Writing Assignments

- Quantitative writing assignments differ both from writing assignments that lack a quantitative dimension, and from "story problems" in math courses.
- Unlike conventional (non-quantitative) writing assignments, QW assignments require students to analyze and interpret quantitative data. Writers must use numbers in a variety of ways to help them define a problem, to see alternative points of view, to speculate about causes and effects, and to create evidence-based arguments. Often they must learn to construct and reference their own tables or graphs.
- Quantitative writing generally presents students with an 'ill structured problem,' requiring the analysis of quantitative data in an ambiguous context without a clear right answer. Unlike a math "story problem," which is usually a 'well-structured problem' with a single right answer, a QW assignment requires students to formulate a claim for a best solution and support it with reasons and evidence.
- Quantitative writing forces students to contemplate the meaning of numbers, to understand where the numbers come from and how they are presented. Students must consider, for example, the different effects of using ordinal numbers versus percentages, means versus medians, raw numbers versus adjusted numbers, exact numbers versus approximated or rounded numbers, and so forth. At more advanced levels, students must understand the interpretive meaning of a standard deviation, the function of a chi square, or the purpose of specific kinds of algorithms in their disciplines. In all cases, they must consider their communicative goals and their audience's interests, needs, and background and to use numbers effectively within that rhetorical context.

Types of Quantitative Writing Assignments

Quantitative Writing doesn't have to mean writing a research paper. In fact, the majority of QW assignments are less ambitious than that. QW assignments can be designed in a variety of forms as indicated below.

- Genre, audience and purpose - Good writing assignments include a rhetorical context for authors: What form should the writing take, to whom is it addressed and for what rhetorical purpose?

- Length, stakes and complexity - QW assignments can range from very short to very long; they can be weighted little or much towards a student's grade; and they can employ simple or complex quantitative reasoning.
- Informal writing - Quantitative writing need not be formal writing.
- QW in formats other than essays - QW assignments need not be papers, per se.

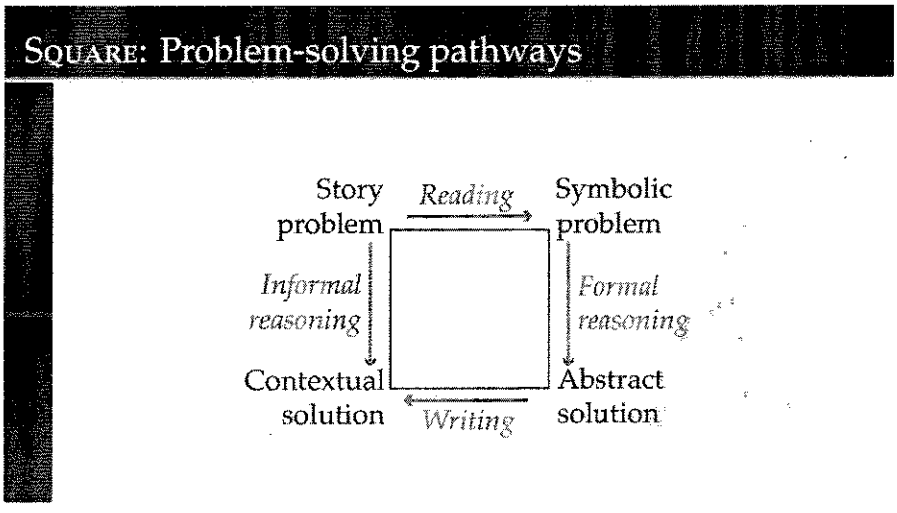
Example of a Quantitative Writing Assignment

The following contains the core sentences from a representative QW assignment.

"Over the last century, the number of salmon that return to California rivers has been decreasing. Is this a serious problem? Should anything be done in response to this situation? You will investigate questions like this in your essay. The table below gives data for the number of Chinook salmon (in thousands) from 1986 to 2000."

This challenging assignment asks students to create an argument about salmon based on tabular data that students must analyze and interpret. To do the assignment, students must make inferences from the table, do calculations, convert tabular data to bar or line graphs, and then use the data meaningfully in their own arguments. The quantitative methods required are only moderately complex, but the questions posed "Is this a serious problem? Should anything be done?" make clear that this is an ill-structured problem.

Excerpt from Salomone, M. (2012) *Why Write in Math?*



Informal Style:

- In-class responses (Focused or free writing)
  Daily, low-stakes (informal, often ungraded writing) assignments can help students to process key ideas in a course reading and prepare them for class discussion. Students might be given a graph and asked to jot down several conclusions based on the data. Informal

writing assignments could ask students to translate a theoretical concept into their own words; or students might offer examples of how a model or theory operates in their own lives.

- Metacognition (process-oriented)
  One way to make quantitative data relevant to students is to ask them interpret data gathered from their lived experience and then reflect on their findings in a report or proposal. For example, students in a Health and Nutrition course recorded and analyzed their food intake over two days, researched the nutritional value of their diets, and wrote up recommendations for improving their nutrition.

- Reading logs/ journals
  As a way of preparing for exams, students can respond in learning journals to specific writing prompts related to course readings and lectures. Journals can be used to verify students' understanding of difficult concepts or theories and a place where they can grapple with calculating and representing (through charts/graphs or statistical summaries) quantitative material.

Formal Style:

- Proofs
- "Writeup problems"
- Summarized readings & annotated bibliography
- Research papers

Scaffolded:

- Open-ended, affective prompts
- Writing about familiar concepts
- Writing about novel and/or advanced concepts

Examples of Quantitative Reasoning Assignments

(Examples from the National Numeracy Network, NICHE and SSAC)

Example 1: Interrogating the Colonial Census in India

Parna Sengupta, Carleton College

Summary

This assignment is meant for an upper division course on colonial and post-colonial India. The assignment, divided into two parts, asks students to consider the decennial census as both a tool of modern (colonial) governance and a source of historical data. The assignment is meant to push students to consider both the ideology behind quantitative data collection as well as a resource that allows scholars to illuminate aspects of history that cannot necessarily be gleaned from more qualitative sources.

Learning Goals

- To give students an opportunity to consider theoretical and historical critiques of the relationship between the gathering of quantitative data and colonialism.
- To acknowledge the critiques and limitations of colonial census data while also recognizing the importance of such data to historians.
- To learn how to ask good historical questions of quantitative sources
- To learn how to represent data in different ways, and how that representation might shape the conclusions we draw from the data.
- To consider change over time, the bread and butter of history itself.

Context for Use

This assignment is given mid-way through an upper-division course in history at a small liberal arts college. It requires some knowledge of colonialism and the ability to read and understand theoretical literature. The assignment asks students to understand and engage with the critiques of historical sources, like the colonial census, in order to productively use census data to ask and answer historical questions. This assignment could certainly be used in other history courses and also productively redesigned so that students might consider census data in different national contexts.

Assignment Description

Part I:

- The first part of the assignment asks students to read some of the theoretical and historical work that has been done on the colonial census in order to get a sense of both the purpose of the census as well as the context of its production. I then have students examine census data over any 50 year period between 1871 and 1941. Using the theoretical literature, students are asked to write a short paper analyzing how the census works as a tool of modern colonial governance.

- Students should pay attention to the kinds of information that the colonial government is interested in. Do these categories change over time?
- Students should consider the different ways that the data is divided: by region, by caste, by religion, by gender, etc. What kinds of inferences can be drawn from the nature of these divisions? Do these categories change over time?

Part II:

- The second part of the assignment has students ask a historical question of the data that they would not be able to ask from more qualitative sources. This part of the assignment is divided into three short sections. Each section asks students to do something different using the data from the decennial census.
- Students should choose a 50 year period from 1871 to 1941. They should then ask a historical question of the data that would address change over time. Students should ask themselves what conclusions they can draw from the data. They should also ask what conclusions they cannot draw from the data.
- The colonial census typically has a long descriptive section that frames the quantitative data that is presented. Choosing one section from one of the decennial censuses, students should consider the degree to which the qualitative description is backed up by the quantitative data that follows.
- The census data is organized in fairly standard tables, but I ask students to take some aspect of the data that they can trace over a fifty year period and consider different ways of visually representing that data. For example, students might present the data represented on a map, as a standard graph, as a bar graph or as a pie chart—on a map, a standard graph, a bar graph, a pie chart, etc. They should then analyze how different visual representations of data changes how we understand that data?

Assessment

Part I

- Students' ability to demonstrate an understanding of the theoretical and historical literature
- Students' ability to integrate those insights into their analysis of the census as a primary source.
- Analytic argument expressed in clear terms in the introductory paragraph.
- Use of evidence to support the analytic claims that are made.
- Conclusion that considers the implications of their analysis.

Part II:

- Students should be able to fulfill each section and demonstrate an understanding of the different ways that quantitative data can be used and represented.
- Each section should clearly explain the student's findings.

- The first section should demonstrate an understanding of how to ask historical questions of quantitative data
- The second section should demonstrate an ability to challenge qualitative assertions by examining the quantitative evidence.
- The third section should demonstrate a student's ability to effectively represent data in different forms. Students should also explain how different conclusions might be reached depending on the manner in which data is presented.

References and Resources

Primary Sources

- Digital Colonial Documents Project (India) Latrobe University: 1871, 1881, 1891, 1901 University of Minnesota (ILL)
- Census of India (1911-2001"every ten years)

Secondary Literature

- Appadurai, Arjun (1993) "Number in the Colonial Imagination" in Peter van der Veer and Carol Breckenridge (eds.) Orientalism and the Post-colonial Predicament, University of Pennsylvania Press, pp. 314-39.
- Cohn, Bernard (1987) "The Census, Social Structure and Objectification in South Asia " in Bernard Cohn (ed.) An Anthropologist Among the Historians and Other Essays. Delhi: Oxford University Press, pp. 224-254.
- Guha, Summit (2003) "The Politics of Identity and Enumeration in India C. 1600-1990" Comparative Study of Society and History, Vol. 45, No.1, pp. 148-167.

Example 2: Utilizing Numbers in Reading and Writing about Socially-Conscious Literature
Sun Hee Teresa Lee, Carleton College

Summary

In this activity students will be given summaries of data related to Native Americans. The data cover such topics as population, health care, education, and family structure. In the first part of the activity, the students will be asked to apply these numbers to their reading of socially-conscious Native American literature. In class, they will then discuss how their understanding of the literature was influenced by the data summaries, and which particular numbers were more useful than others. In the second part of the activity, the students will discuss and practice incorporating numbers in their critical writing.

Learning Goals

- Understand the relevance of numbers in reading socially-conscious literature.
- Acquire the skill of choosing relevant numbers for a particular literature.
- Learn about the appropriate use of numbers in critical writing.

Context for Use

This activity will be implemented in an upper-division course on Native American literature that emphasizes close-reading as well as interdisciplinary critical approaches. In particular, the activity will be part of a unit on Sherman Alexie's socially-conscious book of short stories "The Lone Ranger and Tonto Fistfight in Heaven." Deeply engaged with such issues as alcoholism, domestic abuse, and poverty in Native American communities, the book lends itself well to the use of data related to social issues. After the students have become familiar with the data summaries and the reading, they will be divided into small groups to identify the data that most clearly related to the reading. They will then share their findings with the rest of the class, at which point the class will discuss the relative value of their findings. Afterwards (perhaps in the next class period) students will be asked to think about how numbers could improve the argumentative quality of their writing. They will be given samples of student writing where quantitative information could have been incorporated with success. Since this activity will occur in the middle of the term, the students would be able to think about how their first writing assignment could have been improved with the use of numbers.

Assignment Description and Teaching Materials

Statistical Record of Native North Americans, Marlita A. Reddy, ed., Detroit: Gale, 1993. "Guide to Chapters and Contents," p. xlvii-lxvi.

Teaching Notes and Tips

This activity may be adopted in any lower- or upper-division course where socially-conscious material is taught and writing is emphasized. Depending on class size, the instructor can decide on whether small group work will be best format.

Assessment

The instructor will see during class discussion how well the students are using the data in their understanding of the literature. Furthermore, the activity will be a stepping stone for a larger research project, where students will be encouraged to use quantitative material in their argumentation. The instructor will assess the extent to which numbers played a role in their research papers.

References and Resources

Example 3: Calculating the Tax Break

Robin Davis, Colby-Sawyer College

Summary

Students are presented with a graph or article supporting a political candidate's agenda. They will analyze the information and answer a series of questions designed to help them interpret the information. They will continue their examination outside of class finding the original source of the data for further information. After this initial exercise, the students will find an example of a candidate's use of data to promote his/her agenda. They will examine it as we modeled in class and will write a research paper arguing whether the data does or does not support the candidate's claim.

Learning Goals

- Recognize and understand basic statistical terms
- Report and interpret findings from research
- Critically assess popular press articles
- Detect logical fallacies
- Use Microsoft Excel to create tables, formulas and graphs

Assignment Description

<u>In-Class Activities/Presentations (will also be made available on course Blackboard site)</u>

- Students are presented with an article presenting a presidential candidate's position on a certain issue in graph or numerical form.
- Students generate a list of questions about the data; for example:
    - What is the source of the data?
    - What is the number of participants?
    - How were they chosen?
    - What is the population?
- Presentation on
    - Definitions of common statistical terms (mean, median, mode, standard deviation, variance, margin of effort, validity, and reliability).
    - Activity identifying mean, median, mode, standard deviation, margin of error.
    - Discussion of Gallup polling and sampling.
    - Discussion of false correlations and logical fallacies, causality/correlation/covariance/coincidence.
    - Activity demonstrating false correlations.
- Presentation of example for analysis

<u>Out of Class Assignment</u>

Media Savvy Assignment: We have been discussing leaders'uses of the media and propaganda to advance their images or agendas. As we discussed in class, statistical information can be

interpreted or misinterpreted to suit a leader's position and must be examined carefully. For this assignment, you will do just that.

Step One: The attached table is information provided by the Tax Policy Center and it is this table President Bush referenced in his February 19, 2004 "Remarks by the President on the Economy" [Presidential Hall, Eisenhower Executive Office Building]. Carefully read through the table to complete this assignment.

Step Two: Identify the possible ways the data could be interpreted or misinterpreted by reviewing the data, creating a spreadsheet, and responding to these questions:

1. What is the median income according to the data? [Hint: Remember that median is the value selected so that that half the incomes are larger and half are smaller. What value is that on the table? (Hint, 50% will be lower and 50% will be higher. In what bracket is that value? It will be a bracket, not a value)]
2. What is the tax change (percentage and dollar amount) for those in the median income range? [Hint: Values in parentheses indicate decreases. To get the percentage change, you will need to divide by the income, but it is a bracket. What value doyou think makes the most sense to divide by?]
3. Factor what percentage of each brackets' income the tax cut represents. What income group gets the most tax relief (percentage and dollar amount)?
4. What is the average tax break? [Hint: Here, you cannot just add up the last column because there are different numbers of people in each bracket. You need to weight the average by the number in each category. You can do this by multiplying the tax break by the percentage that will be getting it, then add up that column. The total will be the weighted average.]

Step Three: Using your spreadsheet,

1. Create a graph displaying the percentage of households in each of the income categories. Add the percentage and dollar amount of tax break in each category.
2. Based on your graph, who is getting the best deal?

Step Four: Write a paper from the point of view of a candidate. Take a stand on the issue and use the data go promote your position. What information do you present in your speech to the press if you are in favor of the tax cuts? What information do you present if you are against the tax cuts? You will need to present, describe, and analyze the data in detail to provide adequate basis for your argument.

Format: This is an argument paper and should be structured as such. A minimum of one source will be required to write this paper and probably two sources will be used(the popular press presentation of the data and the original source of the data). The paper should be approximately five pages in length and utilize the Chicago style for proper documentation, refer to your Blair Handbook for more information

Assessment: I will be assessing your knowledge of basic descriptive statistics and your accurate use of statistical concepts in your analysis in addition to your argument.

Assessment

Students will be given a basic pre and post test to assess their knowledge of basic statistical concepts and terms and their application. The argument paper will help me assess the extent to which they are able toapply this knowledge to everyday media and quantitative literacy.

References & Resources

- Political Arithmetik: http://politicalarithmetik.blogspot.com
- Church of the Flying Spaghetti Monster: http://www.venganza.org
- A journalist's guide to interpreting statistics: http://www.robertniles.com
- Gallup Poll FAQs: http://www.galluppoll.com
- FactCheck.org: http://www.factcheck.org/here_we_go_again_bush_exaggerates_tax.html

Example 4: Did You Attend a Good Elementary School?
Janet Bliss, Colby-Sawyer College

Summary

Being a competent teacher includes understanding and recognizing appropriate classroom practices and school policies. Using a constructivist perspective, students must visit and analyze 2 classrooms/schools and determine the appropriateness of the site. One of the classrooms includes a primary grade they attended. The remaining classroom will be a NH site. Using performance standards/criteria from the National Association for the Education of Young Children and the APEEC (Assessment of Practices in Early Elementary Classrooms) scale the students will prepare tables/graphs to summarize comparisons. There will be a variety of considerations requiring them to determine important variables, develop alternative interpretations of the data, and decide if current standards are relevant to children's development.

Learning Goals

- Assess classrooms/schools for developmentally appropriate practices
- Create an appropriate graph of findings
- Gather and analyze information using a variety of sources
- Graphically present findings in class
- Understand how qualitative data can be represented numerically and how
- subjective opinions can influence the numerical data
- Write a paper connected to relevant research

Context for Use

Students require an understanding of child development, developmentally appropriate practices, constructivist theory, and the educational systems intended to support children.

Assignment Description

The assignment will be explained in class and worked on over time. Students will respond to weekly questions on Black Board that will help the instructor gauge their understandings and progress as well as provide feedback accessible to all class participants. Students will be able to engage in Bb dialogue with each other as theygather and share data, analyze the information, and arrive at conclusions.

Using a constructivist perspective, students must visit and analyze 2 classrooms and determine the developmental appropriateness of the site. One of the classrooms is a primary class they attended. The remaining classroom will be a NH site. Using performance standards/criteria from the National Association for the Education of Young Children http://www.naeyc.org/faculty/college.aspand from Assessment of Practices in Early Elementary Classrooms(Hemmeter, M.L., et al, Teachers CollegePress) students will prepare tables/graphs (see http://www.education-world.com/a_tech/techtorial/techtorial025.shtml for help) to summarize comparisons. They will use a variety of resources to gather, analyze and present information. There will be a variety of

considerations requiring them to determine important variables, develop alternative interpretations of the data, and decide if current standards are relevant to children's development.

Student Assignment:

1. Determine 5 criteria from the NAEYC and APEEC that you will use for comparison. Explain why you think these are relevant criteria for a developmentally appropriate environment. Post your explanation on Bb.
2. Visit the 2 classrooms/schools and use the NAEYC and APEEC checklists for appropriate classroom/school practices to collect initial data on the classroom. Record your conclusions about the classroom and the school. Post on Bb.
3. How do the performance criteria support constructivist theory and developmental understandings? What variables might impact classrooms/schools in achieving a positive ranking? Are there alternative ways to interpret the data that could either lower or raise a classroom/school ranking? How will you summarize the quality of the 2 classrooms/schools?
4. Develop a graph that shows a comparison of 5 criteria from the APEEC and NAEYC for ranking school practices. What is the average score for each class?
5. Rate each of the 5 criteria in terms of importance to you, giving a 5 to the most important and a 1 to the least, and use these ratings to develop a revised, weighted average score for each class. To do this, multiply the rating for each criterion by its numerical score as in the tables below. Does this change your overall conclusions about the developmental appropriateness of the 2 classrooms?

Sample Table

Essential Criteria **APEEC** Scale

	Choices for children	Diversity	Physical Environment	Curriculum	Teacher Qualifications
Weighted Rank	5	4	3	2	1
My Class	3.2	5.1	4	1.2	4
NH Class	5.2	3	5.2	6	7.1

Overall score for My Class = (3.2 x 5 + 5.1 x 4 + 4 x 3 + 1.2 x 2 + 4 x 1) ÷ 5 = 10.96
Overall score for NH Class = (5.2 x 5 + 3 x 4 + 5.2 x 3 + 6 x 2 + 7.1 x 1) ÷ 5 = 14.54

Essential Criteria **NAEYC** Scale

	Choices for children	Diversity	Physical Environment	Curriculum	Teacher Qualifications
Weighted Rank	5	4	3	2	1
My Class	3	4	4	2	3
NH Class	4	1	4	4	4

Overall score for My Class = (3 x 5 + 4 x 4 + 4 x 3 + 2 x 2 + 3 x 1) ÷ 5 = 9.2
Overall score for NH Class = (4 x 5 + 1 x 4 + 4 x 3 + 4 x 2 + 4 x 1) ÷ 5 = 9.6

6. Graph the revised, weighted scores and present the graph and your conclusions in class.
7. Is there a set of ratings for the criteria that would change the conclusion about which class is better (according to these criteria)? Put these values in a table to show how the average score would change.

8. Write a short paper (3-4 pages) explaining your use of criteria and results of your investigation. Connect to at least one additional research study on constructivist practices in early childhood classrooms (K-3).

Assessment

As this assignment continues over several weeks with students expected to post things weekly on Bb, I will have continual information on students' ability to collect and analyze data, to interpret and communicate quantitative information, and to think logically. Students will receive prompt feedback from the Instructor, a TA, as well as from peers. Students will present their findings and conclusions in class using graphic representations to summarize the information. Additionally they will submit a paper connecting their conclusions to their investigations of the 2 classrooms.

Students will be assessed on the completion and presentation of their graphs, the application of constructivist theory, the application of the NAEYC and APEEC standards, and their ability to hypothesize appropriate school criteria for excellence.

	Excellent	***Good***	***Basic***
Evaluation of Classrooms & Schools	High level of critical thinking and application of knowledge of constructivist theory, and DAP.	Shows clear understanding of constructivist theory, and DAP. Could have developed thoughts further	Completed assignment but did not demonstrate a clear understanding of constructivist theory, or DAP. Little reflection.
Graphical Representation & Presentation	Demonstrates outstanding knowledge and ease in using technology and analyzing data. Graphs and ideas are clear, creative, and highly appealing. Presentation exemplifies outstanding quantitative analysis, logical and creative thinking, reflection, and imaginative hypothesizing	Demonstrates clear understanding and ease in using technology and analyzing data. Graphs and ideas are well organized and clear with some creativity evident. Presentation demonstrates good quantitative analysis, appropriate logical conclusions, and reasonable hypothesizing	Comfortably used technology and analyzed minimal data. Completes graph but with little creativity or clear organization. Presentation demonstrates a very basic understanding of quantitative analysis and central concepts. Creativity, logical thinking, and reasonable hypothesis are minimal.
Paper	Outstanding writing has original ideas, high level of creative thinking,	Strong writing, well organized, some originality of thought, reflection	Completed assignment with minimal creative thinking. Little

	well connected to a variety of reliable, credible research, imaginative, reflective, and especially well reasoned.	and creativity. Good connection to reliable research using more than 2 sources. Reasonable ideas and conclusions.	original thought, reflection, or application of knowledge. Connections to research are minimal and demonstrate lack of curiosity. Suppositions and conclusions not strongly reasoned.

References & Resources

Example 5: A Look at High School Dropout Rates: Average Rates of Change and Trend Lines
Frank C. Wilson, Chandler-Gilbert Community College

Summary:

In this Spreadsheets Across the Curriculum activity, students calculate the average rate of change and graph a scatter plot of status high school dropout rate for 1975-2003. They compare the average rate of change determined by the total net difference divided by the length of the time period to the slope of the trend line fitted to the data on the scatter plot. In the end-of-module "Show You Know" assignment, the students analyze data for the event highschool dropout rate over the same time period, and they compare the two measures, status vs. event dropout rates. The module combines interpretation of rate of change in the context of a real-world time-series data set with instruction on elementary spreadsheet computation and graphing.

Learning Goals

Mathematics. Students will:

- Calculate the average rate of change by dividing the net difference between the beginning and final values by the duration of the time period.
- Calculate an average of the annual rates of change and find that it is an incorrect measure of the average rate of change when the values represent unequal time intervals.
- Find that although there is an overall average decline in highschool dropout rate (negative sign), there are intervals within the time period when highschool dropout rate increased (postive sign).
- Labor over the wording of rate of change of the dropout rate.
- Draw a scatter plot of the data and find that the slope is not the same as the average rate of change unless the first and last data point fall on the trend line.

Excel. Students will:

- Build a spreadsheet and calculate the average of a column of data.
- Draw a scatter plot of the data and determine the trend line.

Students will:

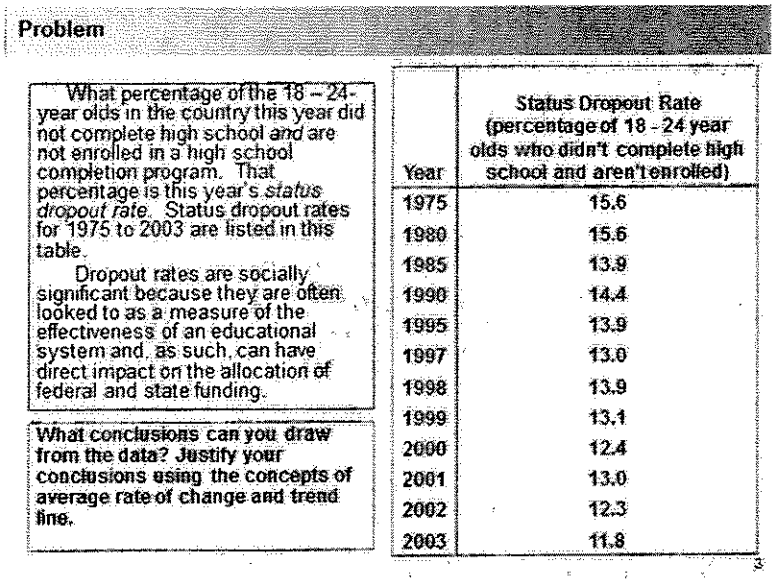
- Look at tables and graphs of highschool dropout rates
- See that there are different measures, namely status dropout rates and event dropout rates.
- In the process of this work, students will come to see that there are nuances, and indeed hazards, in the ubiquitous term "average rate of change."

Context for Use

I plan to use this activity in courses in intermediate algebra, college algebra, and precalculus, where students benefit from working with real-world data. I wrote the module with the intention of its being of interest in courses in education and sociology as well. The general concepts of rate of

change and trend lines have widespread applicability, of course, and the module can be easily adapted to fit the context of other courses.

Assignment Description



Problem

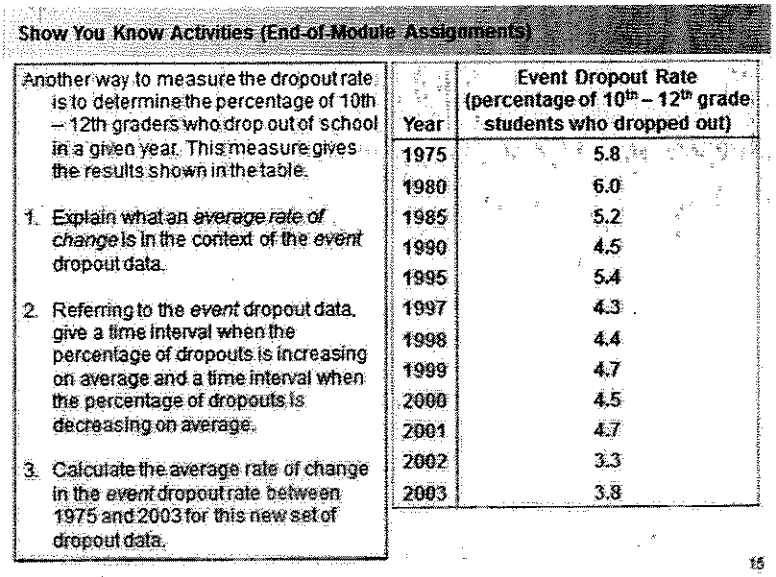
What percentage of the 18 – 24-year olds in the country this year did not complete high school *and* are not enrolled in a high school completion program. That percentage is this year's *status dropout rate*. Status dropout rates for 1975 to 2003 are listed in this table.

Dropout rates are socially significant because they are often looked to as a measure of the effectiveness of an educational system and, as such, can have direct impact on the allocation of federal and state funding.

What conclusions can you draw from the data? Justify your conclusions using the concepts of average rate of change and trend line.

Year	Status Dropout Rate (percentage of 18 - 24 year olds who didn't complete high school and aren't enrolled)
1975	15.6
1980	15.6
1985	13.9
1990	14.4
1995	13.9
1997	13.0
1998	13.9
1999	13.1
2000	12.4
2001	13.0
2002	12.3
2003	11.8

3



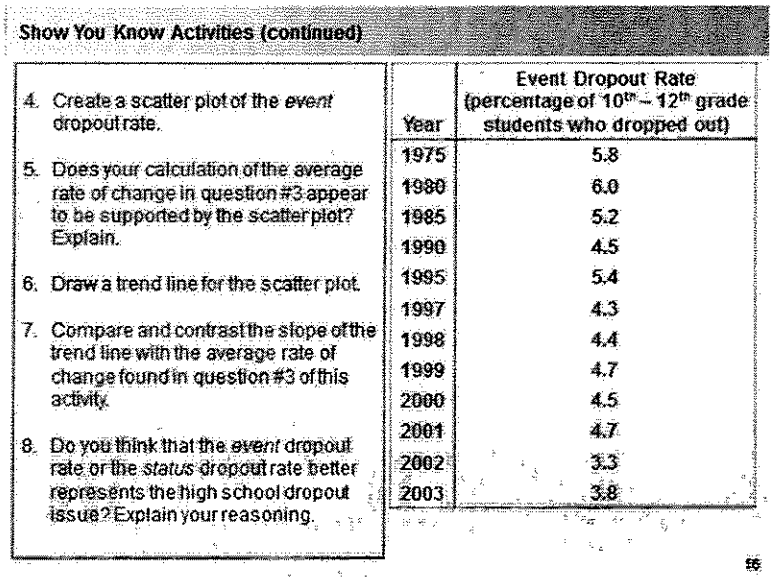
Show You Know Activities (End-of-Module Assignments)

Another way to measure the dropout rate is to determine the percentage of 10th – 12th graders who drop out of school in a given year. This measure gives the results shown in the table.

1. Explain what an *average rate of change* is in the context of the *event* dropout data.
2. Referring to the *event* dropout data, give a time interval when the percentage of dropouts is increasing on average and a time interval when the percentage of dropouts is decreasing on average.
3. Calculate the average rate of change in the *event* dropout rate between 1975 and 2003 for this new set of dropout data.

Year	Event Dropout Rate (percentage of 10th – 12th grade students who dropped out)
1975	5.8
1980	6.0
1985	5.2
1990	4.5
1995	5.4
1997	4.3
1998	4.4
1999	4.7
2000	4.5
2001	4.7
2002	3.3
2003	3.8

15



Show You Know Activities (continued)

4. Create a scatter plot of the *event* dropout rate.
5. Does your calculation of the average rate of change in question #3 appear to be supported by the scatter plot? Explain.
6. Draw a trend line for the scatter plot.
7. Compare and contrast the slope of the trend line with the average rate of change found in question #3 of this activity.
8. Do you think that the *event* dropout rate or the *status* dropout rate better represents the high school dropout issue? Explain your reasoning.

Year	Event Dropout Rate (percentage of 10th – 12th grade students who dropped out)
1975	5.8
1980	6.0
1985	5.2
1990	4.5
1995	5.4
1997	4.3
1998	4.4
1999	4.7
2000	4.5
2001	4.7
2002	3.3
2003	3.8

Other slides available on request.

Assessment

The Show You Know activities at the end of the PowerPoint presentation provide students the opportunity to demonstrate basic skills, explain relevant concepts, and apply the knowledge in a new context. The instructor version includes a pre-test.

References & Resources

Quantitative Reasoning Skill Scaffold

Matt Salomone, Bridgewater State University. Adapted from an Undergraduate Research Skill Scaffold by Jenny Olin Shanahan, the BSU QR Core subcommittee's draft learning outcomes, and Neil Lutsky's 10 Foundational Quantitative Reasoning Questions.

This scaffold may be used at a variety of levels: across phases of a single assignment, across a series of assignments in a course, or across a program. For instance, you might label the columns "Unit 1 — Unit 2 — Unit 3 — Term Paper" or "FYS — Survey — Gateway — Content — Capstone."

Assign each learning outcome and foundational question an appropriate mastery level. Backward–designers may wish to work from right to left!

To Omit (No mark)	**To Introduce** (○)	**To Develop** (◉)	**To Master** (●)
This outcome/question will not be assessed/asked in this context, either because it is inappropriate or irrelevant.	Considered a first exposure. Assessment may be low-stakes, such as writing-to-learn activities. QR is light/peripheral to argument.	Expectations and structure higher. Assessment more open-ended and high-stakes (midterms, responses). QR is less structured and deeper.	Students own this outcome; they are expected to ask this question without prompting. Term paper. QR is central to argument / course.

——————Developmental Progress——————>

Learning Outcome / *Foundational Question*											
1. Develop a set of mathematical skills appropriate to the discipline/context.											
A. What do the numbers show? What else might they show?											
B. What computations are/were appropriate to this question?											
2. Explain and interpret quantitative information in graphs, tables, and words.											
C. What trends and comparisons are suggested? Of what magnitude/import?											
D. How fair is this representation? What biases, if any, does it reveal?											
3. Choose, employ, and discuss the limitations of, a math technique or model.											
E. What is the experimental design? Is it appropriate to the causal claim?											
F. What was controlled for? What possible influences were ignored?											
G. How (and how well) does this generalize? What is its larger significance?											
4. Draw appropriate quantitative inferences, and identify fallacy and half-truth.											
H. What claims are being made? Are the claims appropriately qualified?											
I. How significant is this result? Is there a simpler explanation? (Occam)											
5. Formulate persuasive arguments from quantitative evidence using the above.											
J. Are the conclusions valid and substantiated — correct, complete, concise?											

Assessment

Student Feedback for Quantitative Reasoning

Pre-Evaluation

Based on the Quantitative Reasoning Skill scaffold, this evaluation will determine students' comfort level at the beginning of a course:

1. Develop a set of mathematical skills appropriate to the discipline/context.
    a. What do the numbers show? What else might they show?
    b. What computations are/were appropriate to this question?
2. Explain and interpret quantitative information in graphs, tables, and words.
    a. What trends and comparisons are suggested? Of what magnitude/import?
    b. How fair is this representation? What biases, if any, does it reveal?
3. Choose, employ, and discuss the limitations of, a math technique or model.
    a. What is the experimental design? Is it appropriate to the causal claim?
    b. What was controlled for? What possible influences were ignored?
    c. How (and how well) does this generalize? What is its larger significance?
4. Draw appropriate quantitative inferences, and identify fallacy and half-truth.
    a. What claims are being made? Are the claims appropriately qualified?
    b. How significant is this result? Is there a simpler explanation?
5. Formulate persuasive arguments from quantitative evidence using the above.
    a. Are the conclusions valid and substantiated — correct, complete, concise?

Another example:

1. How often have you practiced analyzing quantitative content of public media (newspaper, magazine, advertising flyer, online material, etc) articles since you finished the Mathematical Reasoning course?
   Never, Rarely, Regularly, or Often.
2. How has your confidence with quantitative reasoning changed since the course?
   Decreased, Stayed the same, or Increased.
3. How has your view of the importance to you of quantitative reasoning changed since the course?
   Decreased, Stayed the same, or Increased.
4. Any other comment?

Mid-Evaluation: Instead of waiting until the end of the semester when it is too late, instead do an anonymous mid-semester survey to see how the class is going.

1. What am I doing to help you learn?
2. What could I be doing better to help you learn?
3. What are you doing to help yourself learn?
4. What could you be doing better to help yourself learn?

QUANTITATIVE LITERACY VALUE RUBRIC

for more information, please contact value@aacu.org

The VALUE rubrics were developed by teams of faculty experts representing colleges and universities across the United States through a process that examined many existing campus rubrics and related documents for each learning outcome and incorporated additional feedback from faculty. The rubrics articulate fundamental criteria for each learning outcome, with performance descriptors demonstrating progressively more sophisticated levels of attainment. The rubrics are intended for institutional-level use in evaluating and discussing student learning, not for grading. The core expectations articulated in all 15 of the VALUE rubrics can and should be translated into the language of individual campuses, disciplines, and even courses. The utility of the VALUE rubrics is to position learning at all undergraduate levels within a basic framework of expectations such that evidence of learning can by shared nationally through a common dialog and understanding of student success.

Definition

Quantitative Literacy (QL) – also known as Numeracy or Quantitative Reasoning (QR) – is a "habit of mind," competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence and they can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate).

Quantitative Literacy Across the Disciplines

Current trends in general education reform demonstrate that faculty are recognizing the steadily growing importance of Quantitative Literacy (QL) in an increasingly quantitative and data-dense world. AAC&U's recent survey showed that concerns about QL skills are shared by employers, who recognize that many of today's students will need a wide range of high level quantitative skills to complete their work responsibilities. Virtually all of today's students, regardless of career choice, will need basic QL skills such as the ability to draw information from charts, graphs, and geometric figures, and the ability to accurately complete straightforward estimations and calculations.

Preliminary efforts to find student work products which demonstrate QL skills proved a challenge in this rubric creation process. It's possible to find pages of mathematical problems, but what those problem sets don't demonstrate is whether the student was able to think about and understand the meaning of her work. It's possible to find research papers that include quantitative information, but those papers often don't provide evidence that allows the evaluator to see how much of the thinking was done by the original source (often carefully cited in the paper) and how much was done by the student herself, or whether conclusions drawn from analysis of the source material are even accurate.

Given widespread agreement about the importance of QL, it becomes incumbent on faculty to develop new kinds of assignments which give students substantive, contextualized experience in using such skills as analyzing quantitative information, representing quantitative information in appropriate forms, completing calculations to answer meaningful questions, making judgments based on quantitative data and communicating the results of that work for various purposes and audiences. As students gain experience with those skills, faculty must develop assignments that require students to create work products which reveal their thought processes and demonstrate the range of their QL skills.

This rubric provides for faculty a definition for QL and a rubric describing four levels of QL achievement which might be observed in work products within work samples or collections of work. Members of AAC&U's rubric development team for QL hope that these materials will aid in the assessment of QL – but, equally important, we hope that they will help institutions and individuals in the effort to more thoroughly embed QL across the curriculum of colleges and universities.

Framing Language

This rubric has been designed for the evaluation of work that addresses quantitative literacy (QL) in a substantive way. QL is not just computation, not just the citing of someone else's data. QL is a habit of mind, a way of thinking about the world that relies on data and on the mathematical analysis of data to make connections and draw conclusions. Teaching QL requires us to design assignments that address authentic, data-based problems. Such assignments may call for the traditional written paper, but we can imagine other alternatives: a video of a PowerPoint presentation, perhaps, or a well designed series of web pages. In any case, a successful demonstration of QL will place the mathematical work in the context of a full and robust discussion of the underlying issues addressed by the assignment.

Finally, QL skills can be applied to a wide array of problems of varying difficulty, confounding the use of this rubric. For example, the same student might demonstrate high levels of QL achievement when working on a simplistic problem and low levels of QL achievement when working on a very complex problem. Thus, to accurately assess a students QL achievement it may be necessary to measure QL achievement within the context of problem complexity, much as is done in diving competitions where two scores are given, one for the difficulty of the dive, and the other for the skill in accomplishing the dive. In this context, that would mean giving one score for the complexity of the problem and another score for the QL achievement in solving the problem.

QUANTITATIVE LITERACY VALUE RUBRIC

for more information, please contact value@aacu.org

Association of American Colleges and Universities

Definition

Quantitative Literacy (QL) – also known as Numeracy or Quantitative Reasoning (QR) – is a "habit of mind," competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence and they can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate).

Evaluators are encouraged to assign a zero to any work sample or collection of work that does not meet benchmark (cell one) level performance.

	Capstone 4	Milestones 3	Milestones 2	1
Interpretation *Ability to explain information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words)*	Provides accurate explanations of information presented in mathematical forms. Makes appropriate inferences based on that information. *For example, accurately explains the trend data shown in a graph and makes reasonable predictions regarding what the data suggest about future events.*	Provides accurate explanations of information presented in mathematical forms. *For instance, accurately explains the trend data shown in a graph.*	Provides somewhat accurate explanations of information presented in mathematical forms, but occasionally makes minor errors related to computations or units. *For instance, accurately explains trend data shown in a graph, but may miscalculate the slope of the trend line.*	Attempts to explain information presented in mathematical forms, but draws incorrect conclusions about what the information means. *For example, attempts to explain the trend data shown in a graph, but will frequently misinterpret the nature of that trend, perhaps by confusing positive and negative trends.*
Representation *Ability to convert relevant information into various mathematical forms (e.g., equations, graphs, diagrams, tables, words)*	Skillfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding.	Competently converts relevant information into an appropriate and desired mathematical portrayal.	Completes conversion of information but resulting mathematical portrayal is only partially appropriate or accurate.	Completes conversion of information but resulting mathematical portrayal is inappropriate or inaccurate.
Calculation	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented elegantly (clearly, concisely, etc.)	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem.	Calculations attempted are either unsuccessful or represent only a portion of the calculations required to comprehensively solve the problem.	Calculations are attempted but are both unsuccessful and are not comprehensive.
Application / Analysis *Ability to make judgments and draw appropriate conclusions based on the quantitative analysis of data, while recognizing the limits of this analysis*	Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions from this work.	Uses the quantitative analysis of data as the basis for competent judgments, drawing reasonable and appropriately qualified conclusions from this work.	Uses the quantitative analysis of data as the basis for workmanlike (without inspiration or nuance, ordinary) judgments, drawing plausible conclusions from this work.	Uses the quantitative analysis of data as the basis for tentative, basic judgments, although is hesitant or uncertain about drawing conclusions from this work.
Assumptions *Ability to make and evaluate important assumptions in estimation, modeling, and data analysis*	Explicitly describes assumptions and provides compelling rationale for why each assumption is appropriate. Shows awareness that confidence in final conclusions is limited by the accuracy of the assumptions.	Explicitly describes assumptions and provides compelling rationale for why assumptions are appropriate.	Explicitly describes assumptions.	Attempts to describe assumptions.
Communication *Expressing quantitative evidence in support of the argument or purpose of the work (in terms of what evidence is used and how it is formatted, presented, and contextualized)*	Uses quantitative information in connection with the argument or purpose of the work, presents it in an effective format, and explicates it with consistently high quality.	Uses quantitative information in connection with the argument or purpose of the work, though data may be presented in a less than completely effective format or some parts of the explication may be uneven.	Uses quantitative information, but does not effectively connect it to the argument or purpose of the work.	Presents an argument for which quantitative evidence is pertinent, but does not provide adequate explicit numerical support. (May use quasi-quantitative words such as "many," "few," "increasing," "small," and the like in place of actual quantities.)

Resources & References

Resources

1. Advanced Mathematical Decision Making (Dana Center, University of Texas)
   http://www.utdanacenter.org/pre-kindergarten-12-education/tools-for-teaching-and-learning/advanced-quantitative-reasoning-advanced-mathematical-decision-making/
   This high-school QR course was adopted as an "alternate" fourth-year mathematics course by the Texas State Board of Education in January 2011.

2. Quantitative Reasoning, Inquiry, and Knowledge (QuIRK) (Carleton College)
   http://serc.carleton.edu/quirk/index.html
   Carleton's portfolio-based, cross-curricular QR program was one of the first and among the most successful of its kind. QuIRK has a wealth of resources on its website to support the development of quantitative coursework and assignments in higher education.

3. Quantitative Reasoning Across the Disciplines (QUAD) (Stockton College)
   http://intraweb.stockton.edu/eyos/page.cfm?siteID=18&pageID=42

4. Quantity Across the Curriculum (QuAC) (Bridgewater State University)
   http://webhost.bridgew.edu/msalomone/quacprogram_com/
   Quantity Across the Curriculum is a faculty-driven program for quantitative reasoning at Bridgewater State University. QuAC's mission is to increase student and faculty engagement and success with numbers in all disciplines of higher education.

5. National Numeracy Network
   http://serc.carleton.edu/nnn/index.html
   The NNN is a professional organization dedicated to promoting issues of numeracy and quantitative reasoning in higher education.

6. Numeracy Infusion Course for Higher Education (NICHE)
   http://serc.carleton.edu/NICHE/index.html
   NICHE is a project of CUNY's Quantitative Reasoning Alliance, and their website is a treasure trove of practical resources for understanding, teaching, and assessing for numeracy skills across the curriculum.

7. SIGMAA QL
   http://sigmaa.maa.org/ql/
   SIGMAA QL is the Special Interest Group of the MAA which focuses on Quantitative Literacy (QL)

8. Radical Math
   http://www.radicalmath.org/
   A resource for educators interested in integrating issues of social and economic justice into

their math classes and curriculum. Also a resource for educators wanting to integrate QL into their courses dealing with issues of social and economic justice!

9. Real World Learning Objects (RWLO)
   http://www.ciese.org/pathways/rwlo/search.php
   The Real World Learning Objects (RWLO) Resource Library is an online repository of Internet-based learning objects designed so that community college faculty can easily access and adapt for use in their classes. Its internet-based activities are focused on discrete topics in higher education mathematics, science, educational technology, and language arts. They can easily be used in similar courses at other institutions to enhance learning and integrate technology in a meaningful way.

10. Social Explorer
    http://www.socialexplorer.com/
    Social Explorer is a premier U.S. demographics website. The site's online tools help users visually analyze and understand the demography of the United States through the use of interactive maps and data reports. The site's primary product is a web-based application that creates fast, intuitive, and visually appealing maps and reports. Anyone with an Internet connection can gain access through the site to census data that was previously the domain of social science experts.

11. Quantitative Environmental Literacy Project (QELP)
    http://www.seattlecentral.edu/qelp/About.html
    QELP's mission is to promote quantitative science literacy and applied mathematics through curricular revision at the college level by linking and integrating mathematics and environmental science. Funded by the National Science Foundation, QELP's main goal is to promote interdisciplinary education between science and mathematics at the beginning college level (first or second year).

12. The Washington Center for Improving the Quality of Undergraduate Education
    http://www3.evergreen.edu/wacenter/home.asp
    The Center is a National Science Foundation funded project that invites faculty from community colleges and research universities to develop and pilot spreadsheet modules to enhance students' quantitative literacy skills. Established in 1985, the Center is a public service center of Evergreen State College.

13. Mathematical Association Of America
    http://www.maa.org/
    This is the site for the Mathematical Association of America, which is the largest professional society that focuses on making mathematics accessible. The Association's mission is to advance the mathematical sciences, especially at the undergraduate college level.

14. Spreadsheets Across The Curriculum (SSAC)
    http://serc.carleton.edu/sp/library/ssac/index.html
    Spreadsheets Across the Curriculum has a large collection of educational spreadsheet modules designed to enhance quantitative literacy wherever quantitative problems arise in the undergraduate curriculum.

15. Science Education Resource Center (SERC)
    http://serc.carleton.edu/index.html
    Site for "Teaching Quantitative Literacy in the Geosciences", part of SERC, the Science Education Resource Center at Carleton College. SERC works to improve science education with a particular emphasis on undergraduate Science, Technology, Engineering, and Mathematics. SERC works with educators across a broad range of disciplines and at all educational levels. The Center has special expertise in effective pedagogies, geo-science education, community organization, workshop leadership, digital libraries, website development and program and website evaluation.

16. The Center For Mathematics And Quantitative Education At Dartmouth
    http://www.math.dartmouth.edu/~mqed/index.php
    The Center for Mathematics &Quantitative Education at Dartmouth, part of the National Numeracy Network, works to establish a collection of materials for teaching quantitative literacy across all disciplines and levels. The materials on the site feature context driven mathematics and are sorted according to level and discipline.

17. Mathematics Across The Community College Curriculum (MAC^3)
    http://www.mac3.matyc.org/books.htm
    Mathematics Across the Community College Curriculum (MAC^3), funded by the National Science Foundation, is dedicated to creating a mathematically literate society to ensure a workforce equipped to compete in a technologically advanced global economy. This project develops training for math and non-math faculty across the disciplines to create, evaluate and modify projects that incorporate mathematics in community college curriculum.

18. STATS
    http://www.stats.org/
    A nonprofit, nonpartisan research organization affiliated with the George Mason University. Its mission is to improve the quality of scientific and statistical information in public discourse and to act as a resource for journalists and policy makers on scientific issues and controversies.

Books

1. *Stat Spotting: A Field Guide to Identifying Dubious Data*, by Joel Best
2. *More damned lies and statistics*, by Joel Best.
3. *Calculated Risks: How to Know When Numbers Deceive You*, by Gerd Gigerenzer

4. *Freakonomics and The Freakonomics Blog*, by Steven Levitt and Stephen Dubner
5. *Innumeracy: Mathematical Illiteracy and its Consequences*, by John Allen Paulos
6. *A Mathematician Reads the Newspaper*, by John Allen Paulos
7. *How to Lie With Statistics*, by Darrell Huff
8. *What the Numbers Say: A Field Guide to Mastering Our Numerical World by* Derrick Niederman & David Boyum
9. *Guesstimation: Solving the world's problems on the back of a cocktail napkin.* Lawrence Weinstein & John A. Adams
10. *The Chicago Guide to Writing About Numbers: The Effective Presentation of Quantitative Information.* Jane E. Miller
11. *NumberSense: How to Use Big Data.* Kaiser Fung.
12. *Thinking Statistically.* Uri Bran & Katie Hshih.
13. *The Numbers Game.* Michael Blastland.

Publications

1. Mathematical Association of America
   http://www.maa.org/programs/faculty-and-departments/curriculum-department-guidelines-recommendations/quantitative-literacy
   a. 2008 Calculation vs. Context: Quantitative Literacy (PDF Format)
   b. 2006 Current Practices in Quantitative Literacy (MAA Bookstore)
   c. 2004 Achieving Quantitative Literacy: An Urgent Challenge for Higher Education. (MAA Bookstore)
   d. 2003 Quantitative Literacy: Why Numeracy Matters for Schools and Colleges. (PDF Format)
   e. 2001 Mathematics and Democracy: The Case for Quantitative Literacy. (MAA Bookstore) (PDF format)
   f. 1994 Quantitative Reasoning for College Graduates. (Report of an MAA Committee)

Web Resources

1. Guide to Writing with Statistics (Purdue University Online Writing Lab)
   https://owl.english.purdue.edu/owl/resource/672/1/
   OWL's rich resource on integrating statistics with writing offers suggestions for "quick tips, writing descriptive statistics, writing inferential statistics, and using visuals with statistics."

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Student Loan Debt Statistics

Here are some important facts about the state of student loans in the United States today:

How many Americans borrow/have borrowed for college?

• Nearly 20 million Americans attend college each year. (Source: **Chronicle of Higher Education (http://chronicle.com/section/Almanac-of-Higher-Education/141/)**)

• Of that 20 million, close to 12 million – or 60% - borrow annually to help cover costs. (Source: **Chronicle of Higher Education (http://chronicle.com/section/Almanac-of-Higher-Education/141/)**)

• There are approximately 37 million student loan borrowers with outstanding student loans today. (Source: **Federal Reserve Board of New York (http://libertystreeteconomics.newyorkfed.org/2012/03/grading-student-loans.html)**)

• As of the first Quarter of 2012, the under 30 age group has the most borrowers at 14 million, followed by 10.6 million for the 30-39 group, 5.7 million in the 40-49 category, 4.6 million in the 50-59 age group and the over 60 category with the least number of borrowers at 2.2 million for an overall total of 37.1 million. (Source: **FRBNY (http://www.newyorkfed.org/studentloandebt/)**)

[illegible] have borrowed for college?

•There is roughly somewhere between $902 billion and $1 trillion in total outstanding student loan debt in the United States today. The **Federal Reserve Bank of New York reports $902B (http://libertystreeteconomics.newyorkfed.org/2012/03/grading-student-loans.html)** while the **Consumer Finance Protection Bureau reports $1T (http://www.consumerfinance.gov/blog/too-big-to-fail-student-debt-hits-a-trillion/)** .

•Roughly $864 billion is outstanding federal student loan debt while the remaining $150 billion is in private student loans(Source: **Consumer Finance Protection Bureau (http://files.consumerfinance.gov/f/201207_cfpb_Reports_Private-Student-Loans.pdf)**). Private student loans are not made or backed by the federal government.

•As of Quarter 1 in 2012, the average student loan balance for all age groups is $24,301. About one-quarter of borrowers owe more than $28,000; 10% of borrowers owe more

than $54,000; 3% owe more than $100,000; and less than 1%, or 167,000 people, owe more than $200,000. (Source: **FRBNY (http://libertystreeteconomics.newyorkfed.org/2012/03/grading-student-loans.html)**)

•In 2010-11, about 57% of public four-year college students graduated with debt. They had borrowed an average of $23,800 (in 2011 dollars). About two-thirds of those earning bachelor's degrees from private nonprofit institutions had debt averaging $29,900. (Source: **College Board (http://trends.collegeboard.org/sites/default/files/student-aid-2012-full-report-130201.pdf)**)

•As of October 2012, the average amount of student loan debt for the Class of 2011 was $26,600, a 5 percent increase from approximately $25,350 in 2010. (Source: **The Project on Student Debt (http://projectonstudentdebt.org/files/pub/classof2011.pdf)**)

Who borrows/has borrowed?

Among all 2007-08 bachelor's degree recipients:
- 66% graduated with some education debt, while 10% had borrowed $40,000 or more.
- 62% at public four-year institutions borrowed.
- 72% at private nonprofit four-year institutions borrowed.
- 96% at private for-profit institutions borrowed.

Associate's degree and certificate recipients, 2007-08:
- 38% of associate's degree recipients at public institutions borrowed.
- 98% of associate's degree recipients at private for-profit institutions borrowed.
- 30% of certificate recipients at public institutions borrowed.
- 90% of certificate recipients at private for-profit institutions borrowed.

Among students who earned graduate degrees in 2007-08:
- 26% had no education debt at all.
- 14% had undergraduate debt but no graduate school debt.
- 7% had borrowed $80,000 or more for graduate school.
- 5% had borrowed between $60,000 and $79,999.

(Source: **The College Board (http://trends.collegeboard.org/student_aid)**)

The majority of borrowers still paying back their loans are in their 30s or older. Of the 37 million Americans with outstanding student loan debt:
- Almost 40% of these borrowers are under the age of 30.
- Nearly 42% are between the ages of 30 and 50.
- 17% are older than 50.
- Borrowers age 30-39 carry $307 billion in student loans, followed by those under 30 at $292 billion, $154 billion in the 40-49 age group, 50-59 at $106 billion and the over 60 category carrying $43 billion, for a total outstanding debt of $902 billion.

(Source: **FRBNY (http://libertystreeteconomics.newyorkfed.org/2012/03/grading-student-loans.html)**)

• Of the 37 million borrowers who have outstanding student loan balances, 14%, or about 5.4 million borrowers, have at least one past due student loan account.

• Of the $870B-$1T in outstanding student loan debt, approximately $85 billion is past due.
(Source: **FRBNY (http://libertystreeteconomics.newyorkfed.org/2012/03/grading-student-loans.html)**)

• The official FY 2010 two-year national student loan cohort default rate rose to 9.1 percent, up from 8.8 percent in FY 2009, while the three-year rate declined slightly from 13.8 percent to 13.4 percent. (Source: **U.S. Department of Education (http://www.ed.gov/news/press-releases/first-official-three-year-student-loan-default-rates-published)**)

• Only about 37 percent of federal student loan borrowers between 2004 and 2009 managed to make timely payments without postponing payments or becoming delinquent.

• For every student loan borrower who defaults, at least two more borrowers become delinquent without default.

• Two out of five student loan borrowers – or 41%- are delinquent at some point in the first five years after entering repayment.

(Source: **Institute for Higher Education Policy (http://www.asa.org/pdfs/corporate/delinquency_the_untold_story.pdf)**)

• As of 2012, there are now more than $8 billion in defaulted private loans, or 850,000 distinct loans in default. (Source: **CFPB (http://files.consumerfinance.gov/f/201207_cfpb_Reports_Private-Student-Loans.pdf)**)

Who struggles most?

• As of early 2012, borrowers in their 30s have a delinquency rate (more than 90 days past due) of about 6%, while borrowers in their 40s have a delinquency rate double that, at about 12 percent. Borrowers in their 50s have a delinquency rate of 9.4% and those over 60 have a delinquency rate of 9.5%.(Source: **Federal Reserve Bank of New York Consumer Credit Panel (http://www.newyorkfed.org/studentloandebt/)**)

Students who drop out of college before earning a degree often struggle most with student loans:
• From 2004 to 2009, 33% of undergraduate federal student loan borrowers who left without a credential became delinquent without defaulting and 26 percent defaulted, vs. 21% with a credential who became delinquent without defaulting and 16% who defaulted.

(Source: **IHEP (http://www.asa.org/pdfs/corporate/delinquency_the_untold_story.pdf)**).

And the number of drop-outs is on the rise:
• Nearly 30 percent of college students who took out loans dropped out of school, up from fewer than a quarter of students a decade ago. (Source: **Education Sector (http://www.educationsector.org/publications/degreeless-debt-what-happens-borrowers-who-drop-out)**)
• More than half of students who take out loans to enroll in two-year for-profit colleges never finish. At traditional nonprofit and public schools, the percentage of students with loans who started college in 2003 and dropped out within six years is about 20 percent. (Source: **Education Trust (http://www.edtrust.org/dc/Subprime)**)

Type of institution attended can also make a difference:
• From 2004-09, a third or less of federal student loan borrowers at four-year, public or private nonprofit institutions became delinquent or defaulted on their loans, while nearly half or more (45 percent and 53 percent, respectively) of their borrowers were making timely payments on their loans.
• One-quarter to one-third of borrowers at for-profit and public two-year institutions were making timely payments on their loans, and more than half of all borrowers in these sectors were delinquent or had already defaulted.
(Source: **IHEP (http://www.asa.org/pdfs/corporate/delinquency_the_untold_story.pdf)**)

Why do they struggle?

• 48% of 25-34 year-olds say they're unemployed or under-employed.
• 52% describe their financial situation as just fair.
• 70% say it has become harder to make ends meet over the past four years.
• 42% of those under 35 have more than $5000 in personal debt that does not include a mortgage.
• Student loans account for the most common form of increasing debt among ages 18-24 (54% have seen increased school loan debt) while those in the older group attribute increased debt equally to school loans (37%) and credit cards (37%).
(Source: **Demos and Young Invincibles (http://www.demos.org/state-of-young-america)**)

How well do students and alumni understand their options to minimize borrowing and manage the debt once they have it?

• As of 2012, only 700,000 borrowers had enrolled in Income-Based Repayment (Source: **Project on Student Debt (http://www.ibrinfo.org/update_61412.vp.html)**), but the Obama Administration estimates that IBR could reduce monthly payments for more than 1.6 million student borrowers. (Source: **White House Fact Sheet (http://www.whitehouse.gov/the-press-office/2011/10/25/fact-sheet-help-americans-manage-student-loan-debt)**)
• About 65 percent of high-debt student loan borrowers misunderstood or were surprised by aspects of their student loans or the student loan process. (Source: **Young Invincibles (http://www.nera.com/nera-files/PUB_Student_Loans_0312.pdf)**)

• Approximately one-third of recent grads, if they could do it all again, would have pursued more scholarships or financial aid options, pursued a major that would have led to a higher paying job, or gotten a job while in college and started saving earlier.
(Source: **Accounting Principals** **(http://www.accountingprincipals.com/Documents/downloads/api-workonomix-survey-post-graduation-2012.pdf)**)

How is student debt impacting borrowers - and the U.S. economy?

A college degree does increase an individual's potential for earnings:
• In 2010, people ages 25 to 34 with bachelor's degrees earned 114 percent more than did those without high-school diplomas.
• College graduates earned 50 percent more than did young adults who completed only high school, and 22 percent more than did those with associate degrees.
• The median income for young adults with a bachelor's degree was $45,000, and with an associate degree, $37,000
(Source: **National Center for Education Statistics** **(http://nces.ed.gov/programs/coe/indicator_er2.asp)**)

But student debt can also negatively impact an individual's ability to take on other consumer debt – and therefore place a drag on the national economy:

• In 2011, first-time home buyers, with a median age of 31, fell to the smallest percentage of total home purchasers since 2006. (Source: **National Association of Realtors** **(http://www.realtor.org/sites/default/files/reports/2011/profile-of-home-buyers-and-sellers-2011-highlights.pdf)**)