ASSESSING QUANTITATIVE REASONING ACROSS THE CURRICULUM

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DR. JESSICA DENNIS, INTERIM DIRECTOR OF ASSESSMENT
WORKSHOP OUTCOMES

• As a result of this workshop you will be able to:

  • Describe the features of quantitative reasoning
  • Adopt a rubric and select assignments for the assessment of these skills
  • Develop a plan for data collection
THE ASSESSMENT CYCLE

Program-Level Assessment

Identifying Student Learning Goals
Aligning Goals with Courses
Gathering Evidence of Student Learning
Interpreting Evidence of Learning
Using Evidence to Improve Learning

Today!
DEFINING AND ASSESSING QUANTITATIVE REASONING
WHY IS QUANTITATIVE REASONING A CORE COMPETENCY FOR UNDERGRADUATE EDUCATION?
Informed citizens must be good consumers of quantitative information!
What foods do I need to eat?

Your genotype suggests that you may have a better response to a weight-loss diet if daily calories come from the following proportions of fat, carbohydrates, and protein. You can monitor this with a diet log.

Based on your gender, age, height, current weight and current activity level, we recommend a diet of approximately 1,829 calories per day to lose weight. This number was calculated estimating your total energy expenditure, or the number of calories your body needs each day. Since you are interested in losing weight, you will need to eat fewer calories than your total energy expenditure.

We suggest a modest calorie reduction of 20 percent. We have calculated this reduction into our calorie recommendation for you, so if you eat around 1,829 calories per day, you can expect to lose weight. This is not a drastic calorie reduction, so you should not feel hungry or like you are denying yourself food if you eat this many calories.

The amount of exercise you get may change your energy requirements. Therefore, you may need to eat more calories than this if you are performing 45 minutes or more of moderate to high intensity cardio exercise on a daily basis.

Here are suggested macronutrient ranges to follow that may optimize the weight loss from your diet.

<table>
<thead>
<tr>
<th>MACRONUTRIENT</th>
<th>RECOMMENDATION</th>
<th>PERCENT</th>
<th>GRAMS</th>
<th>CALORIES</th>
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<tbody>
<tr>
<td>PROTEIN</td>
<td>Choose a reduced calorie diet that is between 20-25% protein. Get your protein from mostly plant food sources such as beans, legumes, nuts, seeds, whole grains and vegetables.</td>
<td>20% to 25%</td>
<td>91g to 114g</td>
<td>366 to 487</td>
</tr>
<tr>
<td>FAT</td>
<td>Choose either a low- or moderate-fat, reduced-calorie diet. Get your fats mostly from plant foods, but avoid excess added oils.</td>
<td>15% to 20%</td>
<td>30g to 41g</td>
<td>274 to 366</td>
</tr>
<tr>
<td>CARBOHYDRATES</td>
<td>You can lose weight on a reduced calorie diet that is either moderate or low in carbs. Choose complex carbs for more nutrients (vegetables, beans, whole grains, etc.) and avoid simple or processed carbs (fruits, chips, crackers, etc.).</td>
<td>55% to 65%</td>
<td>251g to 297g</td>
<td>1,006 to 1,189</td>
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</table>

The total number of calories or grams of each macronutrient shown represents a recommended amount to consume each day.

“Statistical concepts are ubiquitous in every province of human thought. They are more likely to be noticed in the sciences, but they also underlie crucial arguments in history, literature, and religion.”
Digital Humanities:
An emerging field that applies computational tools and methods to traditional humanities

Underwood and Sellers (2012). Emergence of literary diction. *Digital Humanities, vol. 1*
More Americans have died from guns since the beginning of the 21st century than in the Korean War and Vietnam Conflict.
USING QUANTITATIVE REASONING IN EVERYDAY LIFE

• Calculating mortgages and understanding interest rates
• Evaluating colleges
• Sports records
• Recipe conversions/calorie counting
• Comparing prices and deciding how to get the best deal

In the 2013 Handbook of Accreditation, Criteria for Review 2.2a states:

- Baccalaureate programs engage students in an integrated course of study of sufficient breadth and depth to prepare them for work, citizenship, and life-long learning. These programs ensure the development of core competencies including, but not limited to, written and oral communication, quantitative reasoning, information literacy, and critical thinking.

- Institutions are free to define each core competency in a way that makes sense for the institution, its mission, its values, and the needs of its student body.
INSTITUTIONAL LEARNING OUTCOMES AT CAL STATE LA

**Knowledge: Mastery of content and processes of inquiry**
- CSULA graduates have a strong knowledge base in their academic major and can use powerful processes of inquiry in a range of disciplines. They engage contemporary and enduring questions with an understanding of the complexities of human cultures and the physical and natural world and are ready to put their knowledge into action to address contemporary issues.

**Proficiency: Intellectual skills**
- CSULA graduates are equipped to actively participate in democratic society. They are critical thinkers who make use of quantitative and qualitative reasoning. They have the ability to find, use, evaluate and process information in order to engage in complex decision-making. They read critically, speak and write clearly and thoughtfully and communicate effectively.

**Place and Community: Urban and global mission**
- CSULA graduates are engaged individuals who have contributed to the multi-lingual and multiethnic communities that constitute Los Angeles and the world of the future. They are aware of how their actions impact society and the environment, and they strive to make socially responsible decisions. They are community builders sensitive to the needs of diverse individuals and groups and committed to renewing the communities in which they live.

**Transformation: Integrative learning**
- CSULA graduates integrate academic learning with life. They engage in community, professional, creative, research and scholarly projects that lead to changes in their sense of self and understanding of their worlds. Graduates integrate their knowledge, skills and experience to address complex and contemporary issues and act ethically as leaders for the 21st century.
ACTIVITY #1: WHAT IS QUANTITATIVE REASONING?

• In what situations are quantitative skills used in your discipline?

• What are the characteristics of those in your discipline who demonstrates quantitative literacy?

  • List at least 5 traits or dispositions
WHAT IS QUANTITATIVE REASONING?

- WASC frames quantitative reasoning as:
  - The ability to apply mathematical concepts to the interpretation and analysis of quantitative information in order to solve a wide range of problems, from those arising in pure and applied research to everyday issues and questions.
  - It may include such dimensions as ability to apply math skills, judge reasonableness, communicate quantitative information, and recognize the limits of mathematical or statistical methods.
NATIONAL NUMERACY NETWORK

• A comfort, competency, and "habit of mind" in working with numerical data that is as important in today's highly quantitative society as reading and writing were in previous generations.

• A ability that emphasizes the higher-order reasoning and critical thinking skills needed to understand and to create sophisticated arguments supported by quantitative data.

• http://serc.carleton.edu/nnn/index.html
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Criteria for Capstone Proficiency</th>
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<tbody>
<tr>
<td><strong>Interpretation</strong></td>
<td>Provides accurate explanations of information presented in mathematical forms. Makes appropriate inferences based on that information. For example, accurately explain the trend data shown in a graph and make reasonable predictions regarding what the data suggest about future events.</td>
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<tr>
<td>Representation</td>
<td>Skillfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding.</td>
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<tr>
<td><strong>Calculation</strong></td>
<td>Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented elegantly (clearly, concisely)</td>
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<tr>
<td><strong>Application / Analysis</strong></td>
<td>Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions from this work.</td>
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<tr>
<td>Assumptions</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>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.</td>
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</tbody>
</table>
Outcome 1: Use mathematical concepts and quantitative reasoning to solve problems, both in a pure mathematical context and in real-world contexts.

Outcome 2: Interpret information presented in a mathematical form (e.g. equations, graphs, diagrams, tables, words) and convert relevant information into a mathematical form.

Outcome 3: Draw appropriate conclusions based on the quantitative analysis of data, recognizing any underlying assumptions or limits of this analysis.

Outcome 4: Use deductive reasoning in a pure mathematical context to draw conclusions and provide an irrefutable logical justification for them.

Outcome 5: Formulate and communicate a position on a real-world question and use appropriate quantitative information in support of that position, and evaluate the soundness of such an argument.
## AAC&U VALUE RUBRIC FOR INQUIRY AND ANALYSIS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Criteria for Capstone Proficiency</th>
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<tr>
<td>Topic selection</td>
<td>Identifies a creative, focused, and manageable topic that addresses potentially significant yet previously less explored aspects of the topic.</td>
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<tr>
<td>Existing knowledge, research, and/or views</td>
<td>Synthesizes in depth information from relevant sources representing various points of view/approaches.</td>
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<tr>
<td>Design process</td>
<td>All elements of the methodology or theoretical framework are skillfully developed. Appropriate methodology or theoretical frameworks may be synthesized from across disciplines or from relevant sub-disciplines.</td>
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<tr>
<td>Analysis</td>
<td>Organizes and synthesizes evidence to reveal insightful patterns, differences, or similarities related to focus.</td>
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<tr>
<td>Conclusions</td>
<td>States a conclusion that is a logical extrapolation from the inquiry findings.</td>
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<tr>
<td>Limitations and implications</td>
<td>Insightfully discusses in detail relevant and supported limitations and implications</td>
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<td>Central Relevance</td>
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<tr>
<td>Use of numerical evidence is so poor that either it is impossible to evaluate the argument with the information presented or the argument is clearly fallacious. Perhaps key aspects of data collection methods are missing or critical aspects of data source credibility are left unexplored. The argument may exhibit glaring misinterpretation (for instance, deep confusion of correlation and causation). Numbers may be presented, but are not woven into the argument.</td>
<td>The use of numerical evidence is sufficient to allow the reader to follow the argument. But there may be times when information is missing or misused. Perhaps the use of numerical evidence itself is uneven. Or the data are presented effectively, but a lack of discussion of source credibility or methods makes a full evaluation of the argument impossible. Misinterpretations such as the confusion of correlation and causation may appear, but not in a way that fundamentally undermines the entire argument.</td>
</tr>
<tr>
<td>Peripheral Relevance</td>
<td>Fails to use any explicit numerical evidence to provide context. The paper is weaker as a result. This paper shows no attempt to employ peripheral QR.</td>
</tr>
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</table>

For additional information on Carleton’s Quirk initiative, see http://serc.carleton.edu/quirk.
OTHER INFORMATION ON THE QUIRK RATING SHEET

• Problematic characteristics of the QR present in the paper:
  ___ Uses ambiguous words rather than numbers.
  ___ Fails to provide numbers that would contextualize the argument.
  ___ Fails to describe own or others’ data collection methods.
  ___ Doesn’t evaluate source or methods credibility and limitations.
  ___ Inadequate scholarship on the origins of quantitative information cited.
  ___ Makes an unsupported claim about the causal meaning of findings.
  ___ Presents numbers without comparisons that might give them meaning.
  ___ Presents numbers but doesn’t weave them into a coherent argument.

For additional information on Carleton’s Quirk initiative, see http://serc.carleton.edu/quirk.
## QUANTITATIVE LITERACY PORTFOLIO RUBRIC

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<tr>
<th></th>
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<th>Meets Expectations</th>
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<th>Well Below Expectations</th>
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<td>mathematical forms,</td>
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<td>work, though data</td>
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<td>numerical support.</td>
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SELECTING OR DESIGNING ASSIGNMENTS FOR ASSESSMENT
ASSIGNMENT OPTIONS

• Standardized assessments
• Exams or embedded exam items
• Written assignments used in specific courses:
  • Lab assignments
  • Research projects
  • Thesis papers or capstone projects
• Signature assignments designed for assessing specific outcomes for use in multiple sections of a course
• Portfolios representing a variety of assignments
STANDARDIZED ASSESSMENTS

• National Assessment of Adult Literacy
  • http://nces.ed.gov/naal/
• Assessment Resource Tools for Improving Statistical Thinking (ARTIST) and Comprehensive Assessment of Outcomes in a first year Statistical Course test (CAOS) tests:
  • https://apps3.cehd.umn.edu/artist/index.html
• California Critical Thinking Skills Test with Numeracy
  • http://www.insightassessment.com/
• Other examples of assessment instruments:
  • https://serc.carleton.edu/NICHE/ex_qr_assessment.html
QR WRITING ASSIGNMENTS: TYPE 1

• Require students to use evidence from a provided source with multiple charts and tables or from sources they choose themselves.
  • Intro. to Latino/Latina Studies assignment that asks students to find "stories" within a census table summarizing educational attainment by race and gender.
  • An economics assignment asking to analyze the employment effects of the minimum wage using a theoretical model of supply and demand and data from the Statistical Abstract of the United States.
WRITING ASSIGNMENTS: TYPE 2

• Require students to collect their own data to analyze.
  • Natural science lab reports.
  • Sociology assignment requiring students to keep and then analyze a time diary.
  • A first-year seminar that asks students to tally and explore prevalence of social behaviors at a local city festival would also fit this type.
WHAT IS A SIGNATURE ASSIGNMENT?

• Embedded in a course
• Used for course grade and program assessment
• Aligned with Program Learning Outcomes
• Collaboratively designed by faculty
• Meaningful and integrative

• Why?
  • Allows a program to assess learning across course sections or instructors
  • Creates consistency
  • Useful for assessing course sections with different modalities/pedagogies
SOME FOUNDATIONAL QUANTITATIVE REASONING QUESTIONS

• What do the numbers show?
  • Is there numerical evidence to support a claim?
  • How can seeking and analyzing numbers illuminate important phenomena?
  • How plausible is a possibility in light of data?

• How representative is that?
  • Are there meaningful subgroups?
  • What’s the central tendency? What are the odds? What is the base rate?

• Compared to what?
  • What’s the unit of measurement?
  • What is the implicit or explicit frame of reference?

• Is the outcome statistically significant or likely to be due to chance?

• What’s the effect size?
  • How large is the difference?

• Are the results those of a single study or of a literature?

• What’s the research design (correlational or experimental)?

• How was the variable operationalized?

• Who’s in the measurement sample?

• Controlling for what?

See Carleton’s Quirk initiative: https://apps.carleton.edu/quirk/curricular/10questions/
ASSIGNMENTS TO INVITE QUANTITATIVE REASONING

Example 1: Cultural Analysis of Film

• Students choose one of the cultural topics they analyzed in class after viewing three current French films (e.g., education, art, immigration, socio-economic status, communication, spatial boundaries, and social networks).

• Students must first define the very precisely circumscribed phenomenon they will study as they research its statistical significance on a cultural level.

• By integrating socio-economic data analysis and the study of the movie, students evaluate the worth of the fiction as a faithful or distorted mirror of its society.

https://serc.carleton.edu/quirk/quantitative_writing/examples/33554.html
ASSIGNMENTS TO INVITE QUANTITATIVE REASONING

Example 2: Teaching Economics Students to Assess the State of the Economy

• Students are asked to collect and analyze data on a few macro economic aggregates to give them a first taste of empirical work.

• Students must create data tables and charts using a spreadsheet, and draw conclusions based on three variables which may be telling somewhat different stories. Critical decisions include which measures of GDP Growth, inflation, and unemployment to choose, and how to weight them in reaching a conclusion about the overall state of the economy.

https://serc.carleton.edu/quirk/quantitative_writing/examples/31123.html
ACTIVITY #2: QUANTITATIVE WRITING EXAMPLES

• View some examples of QR writing assignments from a closely related discipline to your own:
  https://serc.carleton.edu/quirk/quantitative_writing/examples.html

• What kind of writing assignment could be used for assessment of quantitative reasoning among majors in your program?

• In which course(s) could this assignment be given?
DEVELOPING YOUR PLAN OF ACTION
WHERE ARE THESE OUTCOMES TAUGHT IN YOUR CURRICULUM?

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I = Introduced; D = Developed/Reinforced; M = Mastered
# CHOOSE COURSES TO CONDUCT ASSESSMENTS

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<th>PLO</th>
<th>1500</th>
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I = Introduced; D = Developed/Reinforced; M = Mastered
GATHER AND EVALUATE

Student Assignments

Course #1 Instructor

Grade to students

Student Assignments

Course #2 Instructor

Grade to students

Student Assignments

Course #3 Instructor

Grade to students

Team of Faculty Score Assignments

or

Course Instructor(s) Score Assignments

Assessment Coordinator or Committee Compile Results

Program Faculty Reflect on Results
CHOOSING AND MODIFYING RUBRICS TO MEET YOUR NEEDS

• Decide on minimum criteria for proficiency.

• VALUE rubrics use this terminology:
  • Capstone- culminating level of achievement expected for baccalaureate degree
  • Milestones- progressively more sophisticated performance

• Not intended for 1 = freshmen, 2 = sophomore, or 4 = A, 3 = B, etc.
MODIFYING RUBRICS

• Rubrics must be modified for each project

• Add more specific criteria based on your program or assignment

• Add new dimensions to reflect issues important to your program
SCORING ASSIGNMENTS: RUBRIC CALIBRATION

• Hold a calibration session with all instructors or faculty scorers.
• Begin with a close reading of the rubric and identify areas of discussion.
• Faculty should come to an agreement on interpretation of language in rubric.
• Faculty are given an example of student work to score.
• Discuss scores row by row. Faculty provide rationale for their scores and try to reach consensus.
• Goal is to identify two scores around with the majority cluster.
• Repeat with more examples of student work (high, low, medium)
# DOS AND DON’TS OF DATA COLLECTION AND ANALYSIS

**DO**

- Form a department assessment committee charged with regularly collecting and disseminating data
- Ask for faculty volunteers
- Give faculty early notice regarding assessment plans
- Collect CINs or other information so you can disaggregate results across populations
- Conduct a norming session for the use of the rubric
- Protect the confidentiality and anonymity of students and faculty by examining results at the group level
- Use results to inform changes

**DON’T**

- Wait until the last minute
- Pressure faculty to comply with assessment activities
- Use assessment results to call attention to, judge, or punish individual faculty or students
- Expect perfection
- Collect more data than you can use
USING RESULTS TO CREATE A CULTURE OF EVIDENCE

• Use results:
  • To examine skill development across the curriculum
  • To examine curriculum content coverage and areas for program modification
  • To improve instruction and introduce new pedagogies
    • Contact CETL for resources and support
  • To improve and refine your assessment process/methods
ACTIVITY #3: ASSESSMENT PLAN

• What assignment or activity will you use?
• How will you score student achievement?
• What classes would you target for sampling and when?
• Which faculty will be responsible for coordinating data collection? Data analysis?
• How will you analyze the results? Will you disaggregate results in some way?
• How will results be shared, discussed, and used to make changes?
CAL STATE LA’S COORDINATED QR ASSESSMENT PROJECT 2018-2019

• Goal is to collect evidence of QR at the upper division level across programs.

• Participating programs will develop their own signature assignments or select assignments from courses.

• The university assessment team will develop a rubric with input from the Educational Effectiveness and Assessment Council.

• Programs will be invited to use the rubric and participate in norming sessions in the spring.

• Programs will score their own assignments and submit results by fall 2019.
ADVANTAGES TO PARTICIPATION IN THE QR ASSESSMENT PROJECT

• Contribute to an institutional effort to understand how quantitative reasoning is conceptualized across disciplines.

• Provide a common metric to discuss QR and promote the development of these skills across the curriculum from GE to upper division.

• Opportunity to participate in a norming session and learn how to coordinate the use of rubrics.
QUANTITATIVE REASONING RESOURCES

• Carleton Quantitative Inquiry, Reasoning, and Knowledge (QuIRK) initiative:
  • https://apps.carleton.edu/quirk/design/resources/

• Assessment Resource Tools for Improving Statistical Thinking (ARTIST):
  • https://apps3.cehd.umn.edu/artist/index.html

• Numeracy Infusion Course for Higher Education:
  • https://serc.carleton.edu/NICHE/ex_qr_assessment.html
Other Resources and Credits

- Cal State LA Assessment Resources website:
  - [http://www.calstatela.edu/apra/assessment-resources](http://www.calstatela.edu/apra/assessment-resources)

- “Quantitative Reasoning: The Final Frontier of Core Competencies” Presentation slides by Elrod, S. at the 2016 WASC Senior College and University Commission: 5 Core Competencies Workshop in Pomona, CA.

- Signature Assignment Resources:
  - “Using the VALUE Rubrics for Improvement of Learning and Authentic Assessment” by Rhodes & Finley (2013) Association of American Colleges and Universities
  - “Using Signature Assignments for Program-Level Assessment” Presentation Slides by University of Hawaii, Manoa
  - University of Texas signature assignments webpage:
    - [https://ugs.utexas.edu/sig/plan/samples/writing-model4](https://ugs.utexas.edu/sig/plan/samples/writing-model4)