11/05/2014

TO: Faculty at all UH campuses
FROM: UH Mānoa Quantitative Reasoning Working Group
RE: Request for feedback and constructive comments on draft

Request for feedback and constructive comments on Quantitative Reasoning
Draft Definition and Draft Hallmarks
The UH Mānoa Quantitative Reasoning Working Group (QRWG) asks for feedback and constructive comments on a draft definition of quantitative reasoning (QR) as well as draft hallmarks for a quantitative reasoning course. These truly are drafts—we want your feedback and we will use the responses we receive to revise.

Please email your feedback and constructive comments to qrwg.hawaii@gmail.com.

Background
Faculty at UH Mānoa want all undergraduates, regardless of major, to exit with quantitative reasoning (QR) competency and to be able to use this competency in upper-division courses and in their personal and professional lives. In addition, to remain accredited by the Western Association of Schools and Colleges (WASC), UH Mānoa must demonstrate that students have QR competency. Thus, the UH Mānoa Quantitative Reasoning Working Group (QRWG), with faculty from across the curriculum, was formed in February 2014 at the request of the Mānoa Faculty Senate Executive Committee, General Education Committee, Foundations Board, and the Vice Chancellor for Academic Affairs. Our charge is to create a way for the required undergraduate curriculum to offer students sufficient opportunities to develop quantitative reasoning (QR) skills.

On April 11, 2014, the QRWG introduced its work and distributed a draft definition of QR to faculty at all UH campuses via UH Announce (email subject line: UH Manoa Quantitative Reasoning Working Group (QRWG)). We also asked faculty to provide examples of QR competencies that they believe undergraduates should have. Based on the responses we received and information from expert sources, we revised our working QR draft definition and then drafted a set of statements that describe the QR competencies: these are essentially draft hallmarks of a QR course, and they are listed below as Draft Quantitative Reasoning Hallmarks. We seek your feedback on the draft definition and draft hallmarks.

The expert sources we consulted include the following:
- Syllabi, assignments, course descriptions, including StatWay, QuantWay, Math 100, Math 132, science courses that require quantitative reasoning and financial literacy initiatives
- Association of American Colleges & Universities’ Quantitative Literacy VALUE rubric
- Common Core Math Standards, grades 9-12 Recommendations from the Mathematical Association of America
- Publications such as Health Literacy and Numeracy and Mathematics and Democracy

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Draft Quantitative Reasoning Definition

The draft below is an adaptation of the WASC definition\(^1\) that we modified based on feedback we received from faculty at UH campuses and information from expert sources.

Quantitative reasoning (QR) is the ability to apply mathematical concepts to the interpretation and analysis of quantifiable information in order to solve a wide range of problems, from those arising in pure and applied research to everyday issues and questions. It includes the ability to do the following: apply math skills; judge reasonableness of results; understand and communicate numerical information via variables and equations, graphs and charts, words/sentences; and recognize the limits of mathematical or statistical methods.

[Note: quantifiable information can be expressed numerically or graphically]

Draft Quantitative Reasoning Hallmarks

To satisfy a Quantitative Reasoning requirement, a course will meet these hallmarks:

1. include practical quantitative reasoning problems that apply to specific disciplines, daily and civic life, and/or professional settings (i.e., not be purely theoretical).

2. provide opportunities for practice and feedback that are designed to help students evaluate and improve quantitative reasoning skills by including a course component with a 30:1 student to teacher ratio (e.g., a lab/recitation section, Supplemental Instruction session, or a class limited to 30).

3. be designed so that students will be able to\(^2\)
   
   A. select and convert relevant quantitative information into various forms such as equations, graphs, diagrams, tables, words;
   
   B. make and evaluate important assumptions in estimation, modeling, and data analysis;
   
   C. calculate (including correct manipulation of formulas);
   
   D. make judgments and draw appropriate conclusions based on the quantitative analysis of data, the assumptions made, the limitations of the analysis, and the reasonableness of results;
   
   E. create logical arguments supported by quantitative evidence; and
   
   F. communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate).

We have included additional information and examples at the end of this document.

\(^1\) WASC, the Western Association of Schools and Colleges, published its definition of quantitative reasoning in its 2013 Handbook on Accreditation. See page 52 (Glossary) of the March 2013 edition.

\(^2\) The statements listed here are adapted from the Association of American Colleges & Universities’ Quantitative Literacy VALUE rubric.

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QRWG Next Steps
After we receive feedback and constructive comments from faculty, we will revise the draft definition and draft hallmarks. With the revised definition and revised hallmarks in hand, we will ask faculty at all UH campuses whether existing courses are aligned with QR hallmarks (including courses that currently satisfy Foundations Symbolic Reasoning and courses that do not).

Using all information gathered from multiple sources, we will draft an implementation plan that does the following:

a) ensures that UH Mānoa undergraduates, regardless of major, have sufficient opportunities to develop QR skills;
b) meets WASC accreditation requirements; and
c) allows students to be able to graduate in four years/120 credits by not adding to the existing requirements and by building mechanisms for seamless transfer.

We will present the plan to stakeholders at UH Mānoa and in the UH system.

Thank you in advance for providing us with feedback.

If you have questions, please contact us at qrwg.hawaii@gmail.com.

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Additional Information and Examples

The quantitative reasoning draft definition and draft hallmarks emphasize practical application of QR knowledge and skills. The course will include assignments that give students opportunities to develop QR skills in the context of daily and civic life and/or professional settings. Ideally, the course will be limited to 30 students so that adequate individual feedback can be provided to each student (the lecture + recitation model is an option).

At a minimum, the course might teach students to do things such as the following:

- **Statistics such as chi-square.** For example, the course might ask students to analyze a manufacturing situation in which a cereal manufacturer wants to produce a cereal with a certain proportion of red, white, and blue pieces. The student is asked to ascertain how much the proportion of colored pieces can deviate from the expected proportion before it indicates problems in the production process.

- **Calculate, create logical arguments using quantitative evidence, and communicate.** For example, students might be given this scenario: Mahina is a cello player in the Hawai‘i Symphony. The musicians have been offered three options for raises in a 2-year contract:

<table>
<thead>
<tr>
<th>Option</th>
<th>Salary increase in 1\textsuperscript{st} year</th>
<th>Salary increase in 2\textsuperscript{nd} year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td>8%</td>
</tr>
<tr>
<td>3</td>
<td>8%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Under what conditions would Mahina want Option 1, 2, or 3? Would her choices be the same if instead of an individual musician she was an official representative of the musician’s union? Does it matter if the Hawai‘i Symphony is doing well financially or not?

- **Understand personal financial capability (interest rates, savings and investment portfolios, mortgage rates, loans, and credit debt and score).** For example, the course might ask students to help a journalism major who wants to start an online proofreading/editing company. Because starting a business requires a loan, students design a plan to apply for a loan. The students present a well-researched plan that includes the following: 1) the criteria that lenders use in making small business loans, 2) the typical size of a small business loan, 3) description of the necessary personal information, 4) a budget plan, 5) market trends, size, and predicted growth, and 6) an argument (written and mathematical) demonstrating that the plan will grow the business, and.

- **Apply mathematical models, use algebra, and understand the effects of variables and constants in a formula.** For example, the course might give two different formulas to model the dosages needed to calculate children’s chemotherapy. Children’s Body Surface Area can be calculated using the following:

  a) Mosteller’s formula is: \[ BSA = \sqrt{\frac{H \times W}{3600}} \] where \( BSA \) is in \( m^2 \), \( H \) (height) is in \( cm \), and \( W \) (weight) is in \( kg \), and

  b) Sliding scale nomogram (a pharmaceutical company prescribing aid), which is based on the DuBois formula: \( A = W^{0.425} \times H^{0.725} \times 71.84 \) where \( A \) is also Body Surface Area, but it is measured in \( cm^2 \).

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The students could be asked about a case where the Body Surface Area is 16433 cm² and the person is approximately 5’ 7” tall. According to the two given formulas, students would be asked to calculate the person’s weight in pounds, describe which model is easiest to use, if the formulas give the same answer, and what could be reasons for the discrepancies.

- For example, the course might ask students to analyze global positioning based on Pacific Island traditional, wayfinding techniques grounded in celestial navigation (i.e., sun, moon, stars, currents, winds, birds, etc.). The student is asked to determine calculations such as distance traveled, latitude, speed, wind dynamics, and wave trajectories, among others. Students are asked to make an argument for or against a claim and to reason through whether they have sufficient information to make their argument.

- Recognize when a particular quantitative approach and/or result is appropriate and is not appropriate. For example, a course might give students two articles about the housing market in Hawai‘i that include descriptive statistics (mean, median, etc.) on home prices, resident salaries, home sales, etc. Students are asked to explain why median is often used to describe home prices, summarize the authors’ main points, and analyze the articles in terms of accuracy of the presentation of quantitative evidence, the limitations of the analysis, and explain the reasonableness of authors’ conclusions. Students create graphs, pie charts, histograms, and perform statistical analyses to make their points.

- Use quantitative evidence to understand historical changes in literary diction. For example, students might be given a graph from a digital humanities journal that plots the yearly ratio of words that entered English before 1150 against words that entered 1150-1699 for three different genres (poetry, prose fiction, and nonfiction). Students are asked to speculate about what the data suggest about Anglo-Saxon versus Latin diction or about how the three genres diverge over time (with the divergence dating from about 1775).

- Determine when quantitative data support or do not support an argument or statement. For example, students might be given an x-y graph (scatterplot) showing the relationship between reported happiness and household by type that are the results of geotagged tweets in those cities. They are also given the correlation and p-value and the claim that there is a positive correlation between the percentage of married-couple families and the city’s happiness level. Students are asked to make an argument for or against the claim and to determine if they have sufficient information to make their argument.

- Understand estimating with large numbers. For example, the course might ask students to explore Fermi problems. Examples could be to estimate the number of elementary school teachers in Hawai‘i, the number of grains of sand in a volleyball court area on Ala Moana beach, or to represent graphically the national debt ($10.7 trillion over the last decade).

- Read and create graphs, pie charts, histograms, etc., and also perform simple statistical analyses (averages, modes, etc.). For example, a course might give students two columns of data and ask them to select an appropriate type of visual display, create that display with the data provided, and explain both their rationale for that visual display and conclusions drawn from the data.

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