

**A resolution regarding  
replacement of the Foundations Symbolic Reasoning (FS) General Education  
core requirement with a Foundations Quantitative Reasoning (FQ) General  
Education core requirement**

Whereas, many students at the University of Hawai'i at Mānoa struggle with quantitative topics and skills both in class and after graduation; and

Whereas, the Foundations Symbolic Reasoning (FS) requirement in the current General Education core does not mandate sufficient quantitative skills; and

Whereas, students in non-STEM fields may therefore graduate with little or no quantitative training; and

Whereas such a lack of training can negatively impact their upper-division studies as well as their post-graduation success; and

Whereas the Western Association of Schools and Colleges (WASC), the body that accredits the University of Hawai'i at Mānoa, now requires quantitative reasoning to be part of the required undergraduate curriculum; and

Whereas the Quantitative Reasoning Working Group (QRWG) was chartered jointly by the Mānoa Faculty Senate and the Vice Chancellor for Academic Affairs, and has been meeting for over a year to develop a plan to address the issues listed above; and

Whereas the QRWG has produced a definition of quantitative reasoning as well as hallmarks that quantitative reasoning courses would need to meet; and

Whereas many existing FS courses address many of the FQ hallmarks and can be converted to FQ with minor changes, which means students in STEM (and other) fields where specific quantitative courses are currently required will not see any change in their majors' course requirements; and

Whereas it would benefit students if quantitative reasoning courses were to be developed in as many departments as possible; and

Whereas the QRWG has engaged faculty and leadership at Mānoa and other UH campuses and the response received to our efforts and proposed plan of action has been overwhelmingly positive;

**Therefore be it resolved that**

- 1) the Mānoa Faculty Senate recommends that the current Foundations Symbolic Reasoning General Education core requirement be replaced by a Foundations Quantitative Reasoning General Education core requirement to be implemented with the Fall 2018 Freshman class; and
- 2) the Mānoa Faculty Senate recommends that Mānoa offer students enhanced quantitative reasoning learning opportunities in courses beyond the foundational level, starting with General Education Diversification courses that lend themselves to inclusion of quantitative reasoning content; and

- 3) the accompanying document that includes the description, definition, and hallmarks be used to guide faculty in implementing and assessing the Foundations Quantitative Reasoning General Education core requirement and the enhanced quantitative reasoning learning opportunities in courses beyond the foundational level.

## A. Background

The Quantitative Reasoning Working Group (QRWG) began consultation with University of Hawai'i faculty at all UH campuses in April 2014 when the QRWG introduced its work and distributed a draft definition of QR to faculty at all UH campuses via UH Announce (4/11/2014, email subject line: *UH Manoa Quantitative Reasoning Working Group (QRWG)*). We continued system-wide consultation in November 2014 when we distributed a modified draft definition and draft QR hallmarks via UH Announce (11/13/2014, email subject line: *Feedback Requested*). Consultation regarding a proposed change to general education requirements began on February 17, 2015 via UH Announce, email subject line *Feedback Requested*. The QRWG has posted two [FAQs on our website \(2/10/2015 and 11/5/2014\)](#) and an [end of semester report \(5/22/2014\)](#).

In addition, the QRWG consulted in person and by email with targeted individuals and groups, including departments that offer Foundations Symbolic Reasoning (FS) and professors who teach FS, the UHM Council of Academic Advisors, UHM Department of Mathematics, UHM General Education Committee, UHM Foundations Committee, UHM Arts & Sciences Faculty Senate Executive Committee, UHM Deans and Directors, UH System-wide Foundations Committee, and the UH Council of Chief Academic Officers. The QRWG requested feedback from the UHM Associated Students of the University of Hawai'i at Mānoa.

The feedback received has been overwhelmingly positive and constructive. We have used the feedback to modify and improve the draft QR definition and draft QR hallmarks. Sixty-five 65 individual faculty members took the time to email the QRWG and all faculty committees that were contacted provided feedback. To date, the website has received over 2,100 visits since March 2014 (<http://manoa.hawaii.edu/quantitativereasoning>).

The expert sources we consulted include the following:

- Syllabi, assignments, course descriptions, including StatWay, QuantWay, Math 100, 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](#)

During our work, the QRWG has followed these principles:

- a. ensure that UHM undergraduates, regardless of major, have sufficient opportunities to develop QR skills
- b. gather and use feedback from faculty members, faculty groups, and administrators from all UH campuses;

- c. do not increase the overall number of required general education credits/courses and use existing mechanisms for seamless transfer so student graduation in four years/120 credits is possible; and
- d. address WASC accreditation requirements (see WASC's [Educational Quality: Student Learning, Core Competencies, and Standards of Performance at Graduation](#)).

## **B. Description: Foundations requirement and targeted emphasis**

1) General description: Students take one foundational quantitative reasoning (QR) course and QR is reinforced in targeted general education Diversification courses.

2) Changes to General Education core requirements and curriculum

a) Modify the current General Education requirements as follows:

- i) add a Foundations Quantitative Reasoning (FQ) requirement (3 credits) and
- ii) remove the Foundations Symbolic Reasoning requirement (3 credits).

The QR definition is in Section E and FQ hallmarks are in Section F.

b) Reinforce QR in courses across the curriculum that lend themselves to QR, starting with general education Diversification Biological Science, Physical Science, Science Lab, and Social Science courses.

3) Benefits

- a) Students have exposure to QR at the foundational level.
- b) Many existing FS courses address many of the FQ hallmarks (Section F) and can be converted to FQ with minor to moderate changes. In the case of an FS course needing major changes to meet the FQ hallmarks, course renumbering will have to occur if faculty want to apply for the FQ designation.
- c) Reinforcement of QR will occur in targeted courses that lend themselves to QR.
- d) Faculty across the curriculum interested in infusing QR in their courses can and will have resources available. Resources can be found on the [QR website](#).
- e) Builds on the existing general education framework and philosophy.
- f) Does not change the number credits/courses required for graduation.
- g) No change to Focus requirements.
- h) Allows for seamless transfer.
- i) Meets WASC accreditation requirements as well as the quantitative reasoning requirement of the Accrediting Commission for Community and Junior Colleges (which accredits UH community colleges).

4) Challenges

- a) To meet 2b above, faculty need to ensure that QR skills and knowledge are reinforced in non-FQ courses. Creation of a faculty group is likely needed in order to provide necessary resources.
- b) Evidence of learning can be collected from the FQ courses; however, evidence of learning from other courses will be difficult to identify and systematically collect for the purpose of program-level assessment of student learning.
- c) At the foundational level, each FQ course will have a course component with a 30-1 student to instructor ratio (or the class is limited to 30 students). Currently, MATH 100 at UHM does not

meet this hallmark and faculty will need to determine an effective solution. Options include the following: Supplemental Instruction, online tutoring, graduate student assistants, recitation sections.

### C. Articulation and Fulfillment of the Requirement(s)

Quantitative reasoning requirements will be implemented over several years. We plan to have UHM start offering quantitative reasoning courses in 2016-2017 alongside Foundations Symbolic Reasoning (FS) courses. The UHM Foundations Symbolic Reasoning (FS) courses have been approved until summer 2018 and UHM departments can continue to offer them as FS until then. In fall 2018, all entering students will be required to fulfill the new general education requirements. Starting in fall 2018, students who entered UHM prior to fall 2018 will have the option of fulfilling the current general education requirements or “moving up” to the new general education requirements with the quantitative reasoning requirement(s). In fall 2018 and later, students under the previous general education requirements will satisfy the Foundations requirement with a Foundations quantitative reasoning course.

Articulation will follow the UH established procedures. For the procedure on within-system transfer, please read Executive Policy E5.209, [University of Hawai'i System Student Transfer and Inter-campus Articulation](#).

In regards to a Foundations Quantitative Reasoning (FQ) requirement, students who take a course at another college/university that is equivalent to a UHM course have satisfied the UHM requirement that the UHM course satisfies (approved transfer courses are listed in the [UH System Transfer Credit Database](#)). For example, if MATH 150 at “X University” is equivalent to a Foundations Quantitative Reasoning (FQ) course at UHM, students can transfer the MATH 150 from X University to UHM and use that course to satisfy the FQ requirement at UHM. In addition to this course-by-course articulation method, campuses in the UH system can discuss whether a common Foundations program articulation model is beneficial (see Executive Policy E5.209).

Other methods of fulfilling the requirement will be possible and will need additional faculty input and expertise. At the foundational level, these will be considered: Advanced Placement, College Level Examination Program (CLEP), International Baccalaureate, UHM-developed exam score.

### D. Proposed Timeline

Spring 2015	Seek approval from the UHM Faculty Senate for the changes in general education requirements
Fall 2015	Seek approval from the Board of Regents for the changes in general education requirements
2016	Begin QR implementation. Faculty start the process of revising Foundations Symbolic Reasoning (FS) courses to meet Foundations Quantitative Reasoning (FQ) courses; new courses proposed as FQ. Faculty begin infusing QR in appropriate courses. Develop methods for students to satisfy the QR requirement through non-course means such as an Advanced Placement exam score, SAT score, ACT score, a placement test, etc.
2017-Summer 2018	Transition period. Overlap of FQ and FS courses: a course may be FQ or FS and either will satisfy general education requirements. The FS designation officially ends in Summer 2018.
Fall 2018	All entering UHM students have the new General Education Program requirements. Only FQ courses are offered as part of the UHM Foundations requirement. Begin program-level assessment of student learning.

## E. Definition

### **Quantitative Reasoning Definition** (last updated 11/5/2014)

*The definition is an adaptation of the WASC definition<sup>1</sup> 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]

## F. Hallmarks: Quantitative Reasoning Foundations (FQ) course

### **Foundations Quantitative Reasoning Hallmarks** (updated 01/15/2015)

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

1. help students value the relevance and usefulness of quantitative reasoning.
2. include practical quantitative reasoning problems that apply to specific disciplines, daily and civic life, and/or professional settings (i.e., not be purely theoretical).
3. 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 sessions, or a class limited to 30 or fewer students).
4. be designed so that students will be able to<sup>2</sup>
  - a. identify and convert relevant quantitative information into various forms such as equations, graphs, diagrams, tables, words;
  - b. make and evaluate assumptions in estimation, modeling, and data analysis;
  - c. calculate (including selection of appropriate formulas and 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).

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<sup>1</sup> 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.

<sup>2</sup> The statements listed here are adapted from the Association of American Colleges & Universities' [Quantitative Literacy VALUE rubric](#).

## G. Frequently Asked Questions

### 1) Why did UH Mānoa form the QRWG?

Students' quantitative reasoning (QR) skills have been an ongoing concern of UH Mānoa faculty for several years. We want Mānoa students to not struggle when faced with quantitative reasoning. Furthermore, the need for graduates with adequate QR skills has been confirmed by external organizations such as the Western Association for Schools and Colleges (WASC), which accredits the Mānoa campus. The QRWG is motivated by the desire to create useful QR experiences for Mānoa's undergraduates, ensuring that they graduate from UH Mānoa with a sufficient level of competence and a relevant set of skills in QR.

The QRWG members:

- Robert Bachini, Director, Undergraduate Programs, Shidler College of Business (fall 2014-present)
- Lorraine Baron, Assistant Professor, Institute for Teacher Education (fall 2014)
- Dawne Bost, Educational Specialist, General Education Office (spring 2014-present)
- Linda Furuto, Associate Professor of Mathematics Education, Curriculum Studies (spring 2014, hiatus fall 2014, spring 2015)
- Joy Logan, Professor, Spanish (spring 2014-present)
- Miguel Felipe, Assistant Professor, Music (spring 2014-present)
- Michael Nassir, Instructor, Physics & Astronomy [CO-CHAIR] (spring 2014-present)
- Scott Rowland, Specialist, Geology & Geophysics (spring 2014-present)
- Todd Sammons, Associate Professor, English; Faculty Administrator, General Education Office (spring 2014-present)
- Monica Stitt-Bergh, Associate Specialist, Assessment Office [CO-CHAIR] (spring 2014-present)
- Gary Tachiyama, Academic Advisor, Student Support Services (spring 2014)

### 2) What has been the QRWG's process?

For nearly one year, the QRWG has sought feedback from faculty at all UH campuses and consulted expert sources.

Feedback has been received from individual faculty from Hawai'i CC, Honolulu CC, Kapi'olani CC, Kaua'i CC, Leeward CC, UH Mānoa, UH Maui, UH West Oah'u, Windward CC. Feedback has been received from groups such as the Council of Chief Academic Officers, Mānoa Arts & Sciences Faculty Senate Executive Committee, Mānoa Deans & Directors, Mānoa Foundations Board, Mānoa General Education Committee, Mānoa Writing-intensive Focus Board, UH System Foundations Board.

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](#)
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### **3) What if Mānoa does not change its general education requirements to include QR?**

Mānoa must demonstrate that it offers students sufficient QR learning opportunities and must demonstrate that students graduate from Mānoa with QR skills. This is an accreditation requirement as of 2013.

The QRWG weighed a requirement option vs. a no requirement option. A QR requirement(s) will require less faculty time. If Mānoa does not build QR into general education requirements, individual faculty must still document that they offered QR experiences to students, document their evaluation of students' QR skills, and other faculty must still review the documentation on a regular basis, and submit the information as part of the re-accreditation process. The QRWG believes that including QR in the general education requirements is the best route.

### **4) What will be the impact on students?**

Students will be required to complete the same number of credits/courses. The impact will be on what is learned in the first year and in subsequent courses: students will learn about quantitative reasoning as a practical, relevant skill and have opportunities to solve "real-world" and disciplinary problems.

Students will be able to satisfy their QR requirement(s) by taking approved course(s) at Mānoa, at another campus in the UH system, and at a college not in the UH system. Students will also be able to satisfy the requirement through non-course means that will need additional faculty input and expertise to determine: score on an internal or external exam (e.g., Advanced Placement Exam).

### **5) What will be the impact on faculty?**

A quantitative reasoning requirement(s) offers faculty members opportunities to enhance their courses with quantitative reasoning assignments and activities. Departments that offer FS courses will be asked to review their courses and modify as needed to meet the FQ hallmarks. Faculty across the curriculum will be encouraged to include quantitative reasoning in their courses. The Mānoa Foundations Board and the Mānoa General Education Committee will handle FQ in the same manner they handle FS.

### **6) Will there be a gradual implementation of a quantitative reasoning requirement(s)?**

Yes, of course. We plan to have Mānoa start offering quantitative reasoning courses in 2016-2017 alongside Foundations Symbolic Reasoning (FS) courses. The Foundations Symbolic Reasoning (FS) courses have been approved through summer 2018 and Mānoa departments can continue to offer them as FS until then. In fall 2018, all entering students will be required to fulfill the new general education requirements. Starting in fall 2018, students who entered Mānoa in fall 2015-summer 2018 will have the option of fulfilling the current general education requirements or "move up" to the new general education requirements with the quantitative reasoning requirement. In fall 2018 and beyond, students under the previous general education requirements will satisfy the Foundations requirement with a Foundations quantitative reasoning course.

### **7) What is the difference between quantitative reasoning and math?**

The following chart is taken from "Quantitative Reasoning: The Next 'Across the Curriculum' Movement" by Susan Elrod (Figure 2, page 6, *Peer Review*, Summer 2014), and it summarizes the main differences:

<b>Traditional math</b>	<b>Quantitative reasoning</b>
Abstract, deductive reasoning	Practical, habit of mind
Employed in professions such as sciences, technology, and engineering	Employed in every aspect of an alert, informed life
Rises above context	Anchored in context
Objects of study are ideals	Objects of study are ideas
Serves primarily professional purposes	Is essential for all graduates' personal and civic responsibilities

### 8) What is quantitative reasoning? What are the hallmarks of a QR course?

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]

#### *Foundations Quantitative Reasoning Hallmarks* (updated 01/15/2015)

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

1. help students value the relevance and usefulness of quantitative reasoning.
2. include practical quantitative reasoning problems that apply to specific disciplines, daily and civic life, and/or professional settings (i.e., not be purely theoretical).
3. 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 sessions, or a class limited to 30 or fewer students).
4. be designed so that students will be able to<sup>3</sup>
  - A. identify and convert relevant quantitative information into various forms such as equations, graphs, diagrams, tables, words;
  - B. make and evaluate assumptions in estimation, modeling, and data analysis;
  - C. calculate (including selection of appropriate formulas and 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).

<sup>3</sup> The statements listed here are adapted from the Association of American Colleges & Universities' [Quantitative Literacy VALUE rubric](#).



## 9) What QR examples and resources already exist?

Columbia University Quantitative Reasoning courses

<http://bulletin.columbia.edu/general-studies/undergraduates/degree-fulfillment/core/core/quantitative-reasoning/>

Dartmouth College Mathematics Across the Curriculum Evaluation Summary: Mathematics and Humanities Courses (see section III)

<https://math.dartmouth.edu/~matc/Evaluation/humeval.pdf>

Mathematical Association of America: Quantitative Literacy Curriculum and Department Guidelines & Recommendations

<http://www.maa.org/programs/faculty-and-departments/curriculum-department-guidelines-recommendations/quantitative-literacy>

Mathematical Association of America: SIGMAA on Quantitative Literacy—resources, information & faculty development

<http://sigmaa.maa.org/ql/resources.php>

Mathematical Association of America: SIGMAA-QL Newsletter, December, 2014: “A discussion of the past and future of quantitative literacy”; “perspectives on quantitative literacy from across the curriculum”; “reality math”

<http://sigmaa.maa.org/ql/newsletters/14.pdf>

*Mathematics of, for, and as social justice* by Priscilla Bremser, Chawne Kimber, Rob Root, and Sheila Weaver. Chapter 9 in *Social Justice Education: Inviting Faculty to Transform Their Institutions* (2009, Stylus Publishing). Available online via Hamilton Library.

National Numeracy Network: QR Teaching Activities

<http://serc.carleton.edu/nnn/teaching/test.html>

The New Mathways Project Curricular Materials

Project description: <http://www.utdanacenter.org/higher-education/new-mathways-project/new-mathways-project-curricular-materials/>

QR course materials: <http://www.utdanacenter.org/higher-education/new-mathways-project/new-mathways-project-curricular-materials/quantitative-reasoning-course/>

Reality Math (examples from energy, environment, finance, sports)

<http://www.realitymath.org/>

University of Colorado Boulder: Music 4988: The Entrepreneurial Artist

<http://www.colorado.edu/catalog/2014-15/courses?subject=MUSC&number=4988>

Textbooks/Guides:

*Common Sense Mathematics* (textbook for teaching quantitative reasoning to college students)

Currently free, online: <http://quantitativereasoning.net/>

*Math in Society* (mathematical topics for entry-level quantitative reasoning courses for liberal arts majors)

Free, online: <http://www.opentextbookstore.com/mathinsociety/index.html>

*Models of Conflict and Cooperation* (a comprehensive, introductory, game theory text for general undergraduate students)

By Rick Gillman (Valparaiso University) and David Housman (Goshen College)

<http://www.ams.org/publications/authors/books/postpub/mbk-65>

*Quantitative Reasoning: Tools for Today's Informed Citizen*

By Alicia Sevilla and Kay Somers (both, Moravian College)

Originally published by Key Curriculum Press; available now at J Wiley Site

**10) Where did the list of student skills in the Hallmarks come from?**

The list is based on the dimensions in the [Quantitative Literacy VALUE rubric](#) that was developed by teams of faculty experts representing colleges and universities across the United States. The rubric provides performance descriptors for many of the items listed in hallmark #3.

**11) Some of the QR examples appear to use only high-school-level mathematics. Will QR courses be at the college level?**

Yes. The quantitative reasoning courses will require students to apply mathematical tools to complex professional and daily-life scenarios. An analogy is literature: students read the same novel in high school and college. In college, the novel is re-analyzed using advanced tools of literary criticism and student's understanding of the work's themes and context is informed by other college courses and post-secondary life experience.

**12) Does the System Foundations Board need to approve a change in Mānoa's Foundations requirements?**

No. However we acknowledge that a change in Foundations requirements at Mānoa will have an effect on the systemwide committee on Foundations. Thus we will work with faculty on the systemwide committee and at all UH campuses to have simple, efficient student and course transfer procedures.

UH Hilo and Hawai'i Community College already have a quantitative reasoning requirement. Maui College is working on a quantitative reasoning requirement. Because WASC requirements state that campuses need to demonstrate student competency in QR, we encourage all campuses (both 4-year and 2-year) to examine whether their current core/graduation requirements are adequately preparing all students in this area.

*Thank you.*

**Visit our website:** <http://manoa.hawaii.edu/quantitativereasoning>