

## MEMORANDUM

To: Committee on Academic Policy, Esther Kanipe (Chair),  
and Joe Urgo, Dean of Faculty

From: The Quantitative Literacy Committee: Karen Brewer (Chair), Tom Jones, Tim Kelly,  
Mary O'Neill (Director of the QLit Center), Jeff Pliskin, and Peter Rabinowitz; Nat Strout (CAP  
Liaison)

### **Quantitative Reasoning at Hamilton College Strengthening the Requirement**

---

#### **Introduction**

Dean Urgo's charge to the Quantitative Literacy (QLit) Committee in October 2006 was to examine ways in which the quantitative literacy requirement for graduation might be strengthened. The QLit Committee was happy to take up discussion of the issue. Indeed, since the Quantitative Skills Exam became optional for entering students during orientation we have discussed ways to strengthen the requirement among ourselves and with the previous Dean of Faculty. The Committee thinks that now is an excellent time to consider ways to strengthen this requirement to better match the caliber of the students attending Hamilton.

Given the importance of the interpretation of numerical data and the understanding of statistical information in fields of science and social science as well as in a world that seems awash in numbers, the QLit Committee thinks that now is the time to strengthen this requirement. By doing so, Hamilton College can better prepare students for their lives beyond the Hill. It is impossible to predict when they are undergraduates which students will require a facility and comfort with numbers and data when they enter various careers in the arts, humanities, sciences, and social sciences. The Committee thinks that students should continue to build their quantitative skills while in college and that they should discover new ways to appreciate and make use of numerical and symbolic information. Students should learn to pose new questions that can be answered using quantitative reasoning skills and learn to skillfully view numerical data with a critical eye.

#### **Brief History of the Requirement at Hamilton College**

Quantitative Literacy has a long history at Hamilton. In 1979, IBM awarded a grant to the College to study the problem, pointed out by the faculty, of students' deficient quantitative skills. This led to the establishment in 1984 of the QLit Committee and the development of an exam to be given to all entering students. The QLit Center was then established as a peer-tutoring center for students in courses with quantitative components. The Quantitative Literacy Requirement for graduation was voted in by the faculty in 1996 and was maintained, along with the writing requirement, when the new curriculum was enacted.

Before 2004 all entering students would sit for the QSkills exam during orientation. Students who did not pass were required to enroll either in a Q-course before the end of their first year or in a non-credit bearing tutorial. The QSkills exam tests basic skills in algebra, percentages, geometry, and solving word problems typical of 7<sup>th</sup> to 10<sup>th</sup> grade math. Certainly this level of

skills does not match the caliber of students that Hamilton College hopes to attract and admit for matriculation, as was noted by the external reviewers from Williams, Mt. Holyoke, and Union Colleges of the Hamilton College Department of Mathematics in the spring of 2001:

“... the level of quantitative sophistication that satisfies the [Quantitative Literacy] requirement is surprisingly low, given the College’s high expectations for student competence in writing and speaking. The exemption examination tests little more than arithmetic and simple algebraic skills and reveals a rather narrow perspective on what quantitative literacy might entail. Quite frankly, the proficiency necessary to meet Hamilton’s standard seems closer to a minimal high school level than to a level expected from a top-tier liberal arts college... In sum, the quantitative literacy requirement seems more like an entrance requirement (with remediation available when indicated) than a graduation requirement.”

Three years ago, when the committee extended the time a student could fulfill the requirement (it should be completed by the end of the sophomore year), the range of courses was expanded to include 200-level courses in economics, government, and psychology statistics that were required for the majors in these disciplines. This meant that fewer students probably felt that they “had to take a course in math” to fulfill the requirement.

Ever since the QSkills exam became optional in 2004, fewer than 30% of the class sits for the exam, with about 70% of those students passing it. An optional exam did free up more time for individual advising appointments during orientation, but some faculty also used the exam results for guiding placement of students in quantitative courses. For example, poor performance on the exam might indicate that a student might encounter trouble solving problems in introductory chemistry or reading graphs in introductory economics. The utility of the exam for diagnostic purposes was lost when most of the students no longer sat for the exam.

### **The QLit Requirement Today**

Currently, the requirement can be completed by (1) passing (with a 50% or higher) the Quantitative Skills Exam during orientation or before fall or spring pre-registration; (2) enrolling in and passing a non-credit-bearing tutorial; or (3) enrolling and passing a Q-course, one that contains a significant quantitative or mathematical component. With the exception of Symbolic Logic (Philosophy 240), Q-courses are typically in the disciplines in which mathematics is either the specific topic studied or is a tool for solving problems or for computing and understanding statistics. Below are the specific courses that fulfill the requirement for this academic year.

#### Fall 2006

Archeology 106  
Biology 110, 115  
Chemistry 120, 125  
Economics 265, 275, 285

#### Spring 2007

Archeology 106  
Economics 265, 275, 285  
Geology 209  
Mathematics 100, 113, 114, 123

Government 230  
Mathematics 113, 114, 253  
Philosophy 240  
Physics 100, 190, 200  
Psychology 101, 280

Physics 105, 130, 195, 205  
Psychology 101, 280  
Sophomore Seminar 225

### **Quantitative Literacy and Quantitative Reasoning**

The committee has examined a variety of definitions of quantitative literacy. One definition that we find partially useful is “the ability to adequately use elementary tools to interpret and manipulate quantitative data and ideas that arise in individuals’ private, civic, and work lives. As with reading and writing literacy, quantitative literacy is a habit of mind that is best formed by exposure in many contexts.” (R. Gillman, Introduction to “Current Practices in Quantitative Literacy,” The Mathematical Association of America, 2006.)

We propose here that the label “Quantitative Literacy” be replaced with the term “Quantitative Reasoning” (QR) at Hamilton. These terms are nearly the same, but we think that using “reasoning” shifts the attention away from basic (or even remedial) mathematical skills to a habit of mind that involves “an interpretive activity that takes place within a deductively structured framework [and] involves a tapestry of meaning provided by a warp of abstract patterns and a weft of context and story line. In quantitative reasoning, context provides meaning” (George Cobb, statistician).

### **The QLit Committee’s Goals and Findings**

Throughout our discussions, we have kept the following in mind:

- The requirement should be considered as one of the key proficiencies along with writing and speaking; students should leave Hamilton feeling they have increased their quantitative reasoning skills.
- The changes should serve the broad (and demographically changing) range of the student population, including the math-anxious.
- A de-facto math-science requirement is undesirable; the skills that students learn should preferably occur in a breadth of courses across the traditional divisions of the sciences/math, humanities, arts, and social sciences. This will allow more students to develop quantitative skills in subjects in which they already have knowledge and with which they have a strong intellectual engagement.
- There will inevitably be resource issues, including the number of seats in courses required for students to satisfy the requirement. Funding will also be necessary to support faculty to develop new courses, especially in the humanities and the arts, and to add QR components to existing courses. This should include, for example, sponsorship of workshops, summer stipends for course development and incentives for grant writing to expand and support the strengthening of the requirement.

Last year, committee member Jeff Pliskin gleaned some valuable information about the students that entered in the fall of 2001, the first students under the new curriculum. Of the 462 who entered, 389 graduated in 2005 and 1 graduated in 2004. The remaining 72 students either

withdrew from the college or graduated after 2005. So for the class of 2005, we have the following information regarding how they fulfilled the QLit requirement as it currently stands:

- 109 of the 459 students that took the QSkills exam in the fall of 2001 did not pass (24%)
- 32 students took and passed the tutorial in the fall of 2001 and spring of 2002 (7% of the 459 who entered)
- 40 students of the 389 students who graduated in 2005 did not take any Q-courses (but fulfilled the requirement by passing the exam or the tutorial) (10%)
- 349 of the 389 students who graduated in 2005 students took at least one Q-course (90%)
- 69 of the 389 students who graduated in 2005 took only one Q-course (18%)
- 280 of the 389 students who graduated in 2005 students took more than one Q-course (72%)
- 16 of the 73 students who did not graduate in 2005 did not take any Q-courses
- 28 of the 73 students who did not graduate in 2005 took only one Q-course

As proposed below, a one-course requirement might mean that 10% of an entering class would need to be accommodated in a class. A two-course requirement might require 80 (the number of students who did not take a Q-course multiplied by two) plus 69 (the number of students taking only one Q-course) or 149 “seats” in courses. However, it must be kept in mind that if the definition of a Q-course is substantially broadened as described below, the number of additional seats stated here (using the current list of Q-courses) is overstated. It is very difficult to say by how much, however, and it is also impossible to predict where the pressures from enrollment might occur among the different Q-courses offered. We do think, however, that with the broader range of QR courses available, students will be more likely to be able to find a class that is both interesting to them and that satisfies the requirement, easing enrollment pressures.

In a survey of other colleges and universities with Quantitative Literacy programs, we discovered much variability. Some have a minimal requirement of one course, which falls directly under the general distribution requirements of math/science, while others require two courses, one of which is based on proficiency skills (which may be satisfied with a test) coupled with a later applied skills course or an overlay course specifically in statistics. In most cases, the requirement seems to reflect the reality of resources available to develop and support the courses. Several colleges strive to implement quantitative reasoning across the curriculum, much as writing has been, and they have accomplished this often in areas of the physical and natural sciences, the social sciences, mathematics, and computer science.

We have considered several options, from eliminating the requirement altogether to establishing a requirement of several courses. We present two recommendations below. The first, based on a two-course requirement, has our strongest support. The second option, a single course requirement, represents what we think is a minimal strengthening of the requirement. Both options include the elimination of the QSkills exam as a means to satisfy the QR requirement. Satisfying a graduation requirement by passing a basic skills exam with a 50% score or greater before sitting in a college classroom seems feeble to the QLit Committee. College requirements should aim to build skills at the post-secondary level, not place a check mark next to skills that should have been mastered in middle and secondary school. The QR Committee might still need

to develop and administer an assessment for students who are not sure which courses might be best for them. Any exam in that capacity would be for advising purposes only, to help students understand what skills they might need to develop in order to pursue their academic and professional interests.

### **Upgrade Version 2.0**

The Committee strongly recommends that Quantitative Reasoning skills at the college level should be developed over time and in a variety of contexts. The Committee's first proposal for strengthening the requirement, then, is substantial. It requires each Hamilton student to pass two one-credit Quantitative Reasoning courses chosen from two of three categories of broadly defined QR courses:

- Data Analysis (e.g. courses that use data analysis in math, psychology, sociology, economics, natural and physical sciences, and government)
- Logic and Symbolic Reasoning (e.g. courses in symbolic logic, music theory, linguistics, computer science)
- Mathematics and Modeling (e.g. some courses in mathematics, economics, sciences)

If a two-course requirement is implemented, the QR Committee would, of course, have to decide on policies for counting (or not counting) AP or IB credits to partially or fully fulfill the requirement. Also to be decided would be whether the two courses must be taken in different academic departments.

In our survey of QLit/QR programs at other institutions, we found no other college or university that requires two courses for graduation. Wellesley College's QR requirement appears to be a two-course requirement, but most students pass out of the first basic skills required course by passing an examination during orientation. In addition, Wellesley's second overlay course is narrowly defined as a course in data analysis. These courses range from Human Biology to Analytical Chemistry to Introduction to Probability and Statistical Methods to Statistical Analysis of Education Issues.

We propose for Hamilton that all QR courses be broadly defined so as to include any courses that use quantitative methods, data analysis, symbolic reasoning, or modeling. We think that courses in which computer programs are written or musical patterns discerned use very similar reasoning skills to that used in mathematical manipulations and in the organizing and interpreting of data in more traditional QLit courses. We think (hope) that the broadening of the definition of Quantitative Literacy to Quantitative Reasoning in this way will be sound both practically and pedagogically. A quick read of the 2006-07 course catalog for primarily 100 and 200-level "methods" courses might expand the Q-course listing to include:

Anthropology: 114 Fieldwork & Ethnography, 127 Introduction to Linguistic  
Anthropology, 225 Phonetics and Phonology, 280 Archaeological Field Course  
Biology: 200 Scientific Digital Imaging, 248 Genes and Genomes  
Chemistry: 190/255 Organic Chemistry, 265 Inorganic Chemistry  
Communications: 355 Methods of Communication Research

Computer Science: 105 Explorations in Computer Science, 110 Introduction to Computer Science, 111 Data Structures  
Economics: 101/102 Issues in Micro/Macroeconomics  
Education: 350 Ethnography of the Learning Environment  
Geosciences: 103/105/110/112/122 Principles of Geoscience  
Music: 109/209 Theories of Music  
Philosophy: 200 Critical Reasoning  
Physics: 160 Introduction to Astronomy, 130 Physics of architecture, 140 Light and the Laser, 135 Space-Time and the Quantum World, 254 Electronics and Computers  
Sociology: 257 Using Survey Research, 302 Research Methods  
Sophomore Seminars: 202 Infinity and then Some, 210 The Physics of Musical Sound, 218 Space: It's Light, It's Shape, 221 Global Warming, 224 Art and Physics of the Image, 225 Nature, Art, or Mathematics

While this list shows only the range of possibilities, we think all that all students would be able to satisfy a two-course requirement more easily with the addition of courses like these to those that are now designated as Q-courses.. Consultation with Department Chairs and individual faculty members with a formal process of designating a course as satisfying the QR requirement would have to be implemented to compile the actual list of QR courses.

For students who come to Hamilton math-anxious, the current tutorial program would be reconfigured into a one-credit course that would satisfy one of their two required QR courses. It will be necessary to add these reconfigured tutorials as new courses to the curriculum. Designing these courses so that they are valuable and accessible to these students will be of utmost importance. This will require the faculty to look creatively and carefully for appropriate pedagogies and relevant course themes in addition to addressing gaps in a student's mathematical background. Perhaps these reconfigured tutorial courses would be designed around themes such as the mathematics of perspective in art, the elements of statistics for public health, or the graphical display of information. These courses would have to appeal to an audience of math-shy students and truly build logic and quantitative skills for these students to launch them into another QR course.

These new one-credit courses should ideally be taught by full-time faculty, perhaps using the model of Writing 110, in which faculty from various departments participate. These courses should not be perceived as remedial, but as opportunities to open students up to the ways in which quantitative information, analysis, and problem solving are vital to decision-making processes in many fields of work and study. Another model for staffing the reconfigured tutorials might have a large section of the course meet with a faculty member once a week in "lecture" and then meet in smaller groups with a peer tutor who would guide students through various activities related to the course topics at least twice a week. Also acceptable might be hiring a talented and dedicated adjunct faculty member to teach the reconfigured tutorials or creating a Quantitative Reasoning Teaching Fellow position (much like in the foreign languages) for recent graduates who are skilled in mathematics and statistics and interested in teaching as a career.

Last year (2005-06), 18 students enrolled in the tutorial program through the Quantitative Literacy Center. With the elimination of the exam we expect this number to perhaps double. We believe that at the maximum, 50-75 students would enroll throughout the academic year in the reconfigured tutorial. If we expand the list of Q-courses (see above) to include courses in computer science, for example, the number of students we might expect to need to satisfy the requirement via the reconfigured tutorial would be reduced, although by how much is difficult to predict.

Along with the development of the reconfigured tutorials, we think it important that with strong CAP and Dean of Faculty support, faculty across the disciplines will be encouraged (indeed, inspired) to develop new QR courses. The strengthening of the requirement presents an opportunity for faculty to upgrade their existing courses to meet the broadened criteria. In order to help instructors introduce or increase the QR in their courses, we urge the College to support periodic workshops and both on-campus and off-campus consultants. This will help to bring more courses under the umbrella of Quantitative Reasoning and provide on-going faculty development. Funding must be made readily available for instructors to work on existing courses as well as to design new courses during the summer.

### **Upgrade Version 1.0**

The minimal upgrade we recommend for the requirement is that each student complete a one-credit QR course. As described above, the current tutorial program would be reconfigured into a full one-credit course and the list of QR courses could encompass some of the courses on a broadened list as described above. However, it is likely that with students taking only one course to satisfy the requirement, the QR Committee would look to designate courses as QR that contain a greater proportion of a QR component. This might mean an “approved” QR course list that weighs more heavily toward the categories of data analysis and mathematics.

This option to strengthen the requirement is attractive in that it is probably the easiest to predict in terms of needed resources (the reconfigured tutorials need to be staffed), but it is minimal. A single course hardly starts to build further skills nor does it provide students with a broad view of how quantitative information and methods can be used in several fields of inquiry.

### **Designation of QR Courses and Support for a Strengthened Requirement**

Much thinking would have to be done to lay down the specific criteria for QR courses in the three areas for Upgrade Version 2.0. Because we expect QR components of a course to be woven throughout a course, placing a percentage of QR within a course or the minimum number of class hours devoted to QR would be difficult. We cannot envision counting the individual QR components as a percentage of the entire course as one would perhaps count the number of papers assigned for a writing-intensive course. A more global view of the potential QR course would have to be taken by the Committee. If the CAP is interested in furthering this proposal, the QLit (QR) Committee would be happy to draft more specific guidelines. It is fair, however, here to give the CAP a sense of what guidelines/goals might be used generally to designate a course as a QR course.

- QR courses should provide specific instruction to students of the tools of QR needed for analysis and interpretation in the course including computer programming, problem solving methods, statistical terms, etc.
- QR courses should include several hands-on experiences woven into the context of the course (using authentic data if possible) which analyze and interpret data, use symbols to discern patterns and logic, and build and use logical and mathematical models to solve problems
- QR courses should contain enough assignments and in-class/lab experiences at the appropriate level through which students gain greater facility in manipulating data and symbols for computations and interpretation.
- QR courses should include the critical analysis of the QR components of the course. How sure is the result/interpretation? What alternative conclusions can be reached from the data? Is the result logical? Could the solution be written another way?
- QR courses should strive to convince the students of the utility and applicability of the QR component in the course to achieve greater understanding of the topics of the course

The Quantitative Reasoning Committee could take on the added work of a strengthened requirement, possibly to include

- Talking with departments and faculty members about which of their courses meet or may meet criteria as QR courses
- Working with individual faculty to obtain resources for inclusion of QR into their courses
- Working with the Dean of Faculty to run workshops, faculty QR development groups, arrange for outside consultants and speakers, etc.
- Ensuring excellent support for students in QR courses through the QR Center and peer tutors. This may mean expanding the responsibilities of the Director of the QR Center with adequate administrative support and budgeting additional funds for more tutors.
- Designing an assessment for students who are unsure of their quantitative skills strengths and weaknesses.