

Strengthening Quantitative Reasoning: From Campus Conversations to Effective Curricular Reforms

An ACM-Sponsored Conference on the Carleton College Campus September 30 and October 1, 2005

Information from participating colleges regarding QR at their institutions

Augsburg College, Minneapolis, Minnesota

Quantitative Reasoning (QR) and Statistical Literacy at Augsburg College

Augsburg graduates are required to complete a quantitative reasoning skills course. More than 20 courses meet this QR requirement. One such course is Statistical Literacy which is designed for students in majors that don't involve complex mathematical content. Statistical literacy focuses on helping students analyze everyday news stories that use numbers and statistics as evidence. Students learn that while an association between a predictor and an outcome could be due to internal causation, it is often beneficial to focus on alternative explanations. What else might be causing the observed association? Might it be how the statistics were assembled or presented? [See Joel Best's books.] Or context -- what confounders were omitted? Randomness or chance? Error or bias? By focusing repeatedly on these four alternate explanations, students learn to think critically and creatively about arguments that employ statistical evidence. For an overview of this course see "*Statistical Literacy and Liberal Education at Augsburg College*" in the 2004 Quantitative Literacy issue of AAC&U's Peer Review. A Statistical Literacy textbook (under development) is being tested at Augsburg College and Capella University. For more information, see www.Augsburg.edu/statlit and www.StatLit.org. See Jane Miller's, "*The Chicago Guide to Writing About Numbers*." Submitted by Milo Schield, Director of the W. M. Keck Statistical Literacy Project.

- Milo Schield

Carleton College, Northfield, Minnesota

Quantitative Inquiry, Reasoning, and Knowledge (Quirk) Initiative

Carleton College is in the second year of a three year project, supported by a grant from the Fund for the Improvement of Postsecondary Education (FIPSE grant P116B040816) to help students evaluate and use quantitative evidence. We seek to strengthen students' (a) critical appreciation of quantitative approaches to understanding, (b) competence to evaluate implicit and explicit quantitative claims in light of relevant standards and considerations, (c) willingness to use quantitative information electively to help construct and evaluate arguments, (d) knowledge of or knowledge of how to find or generate relevant and sound quantitative information, and (e) ability to represent and communicate quantitative information, evaluations, interpretations, and arguments in a clear, measured, and responsible manner. To accomplish this, we are sponsoring workshops for faculty (e.g., Medical Research and Personal Health, Writing about Numbers), seminars designed to involve first year students in quantitative inquiry (e.g., Measured Thought: Principles of Quantitative Reasoning, Geology and Human Health), and the redesign of existing courses to emphasize quantitative reasoning. To inform and evaluate these efforts, faculty are assessing how (and if) students use quantitative reasoning in

their writing as shown in student papers submitted to meet the College's writing portfolio requirement. Additional information on Carleton's Quirk Initiative can be found at <http://www.go.carleton.edu/quirk>.

- Neil Lutsky

Colorado College, Colorado Springs, Colorado
Quantitative Reasoning at Colorado College (2000-05)

Since 2000 the College has endeavored to establish a learning support system for students challenged by quantitative intensive courses (Intro to Chemistry, Calculus, etc.). A task force studied and then visited other liberal arts colleges with quantitative reasoning programs, an endowment gift (\$1.5 million) was designated to establish a Quantitative Reasoning Center with a director and tutoring services, and a \$350,000 gift was double-matched by the college to renovate a 6000 square foot section of the main library. The Learning Commons at Tutt Library opened in Fall 2004. It includes a spacious study lounge with a view to the campus quad, the Writing and Quantitative Reasoning Centers, two reception areas, a media preparation center, the office of the Disabilities Services Coordinator, the office of the First Year and Second Year Program Director and Advisor, and the office of the Crown Faculty Center director and associated meeting/study spaces. As a step toward hiring a full time director, last year's Quantitative Reasoning paraprofessional (a recent graduate) has become the Interim Coordinator of Quantitative Reasoning.

Efforts in the Quantitative Reasoning Center during AY 2004-05 focused on providing academic support through tutoring and group study sessions. Brief introductory visits to 100-level math and science classes helped to increase the visibility and use of the QR Center in the new Learning Commons. This year the Interim QR Coordinator is also working with paraprofessionals in the math and science departments to coordinate a training program for peer tutors (most current tutors did not have any formal training prior to this program). The Interim Coordinator will also institute new QR related programming which will include establishing a library of tip sheets for students and working more closely with faculty.

In early 2004 faculty approved new general education guidelines that decreased the number of units required in both general education and in all majors, "opening up the middle" for elective courses. The guidelines included a requirement the College identify and designate appropriate courses as "Q" (quantitative reasoning). During 2004-05 the Dean's Office charged a subcommittee to develop a definition of Q that would provide a basis for identifying courses. The committee's definition reads: "Q courses enhance quantitative literacy. In these courses, students will summarize and interpret quantitative data, apply logical and symbolic analysis to complex problems, and/or engage in mathematical modeling." In October 2005 the General Education Oversight Committee will consider revisions to the statement and take a proposed definition to the faculty for a full vote. Once approved, departments will be able to submit courses for the Q designation. Many faculty view this as a step toward an eventual Q requirement.

- Suzanne Kern

Cornell College, Mt. Vernon, Iowa

The Cornell College participants are attending the conference on a fact-finding mission. At this point in time they do not have a QR initiative, nor do they necessarily have plans to start one. But their faculty is stepping back and taking a look at the curriculum as a whole and wondering where they want to be in 10 years. At this point, Cornell has a mathematics requirement for the BA degree. And have just added a staff member in quantitative reasoning to support faculty and students in courses that have a quantitative component (everything from the sciences to Economics, Sociology and Psychology). It is possible that they will think about a QR component to the degree, but will need to become more educated about what that means.

- Ann Cannon, Cornell College, Mt. Vernon, Iowa

Grinnell College, Grinnell, Iowa

Efforts to enhance quantitative reasoning at Grinnell College need to be considered in the context of the college's open curriculum; Grinnell has no college-wide requirements. As such, the college relies on persuasion, incentives and, in some cases, requirements of the major in order to support its efforts to expose students to coursework to refine their quantitative skills. There is considerable student "buy-in" to these efforts.

In this context, Grinnell offers a variety of courses that deal with quantitative reasoning beyond the traditional math and computer science curriculum. The Math/Computer Science Department administers *Introduction to Statistics* (Math 115), a course first developed in the mid-1970s. Presently this course is staffed by the two statisticians in Math/CS as well as by faculty from across the college, especially from the Social Studies Division. Broad, college-wide staffing has always been a hallmark of this course. More recently the Math/CS department statisticians have offered and staffed another introductory statistics course (i.e., Math 209), with calculus as a prerequisite and pitched at a slightly higher level. All of the social science departments except History require one of these courses of their majors; History recommends statistics. Other majors in the Science Division require or recommend a statistics course. In some cases, statistics is a prerequisite for upper-level courses in a major. Economics, in addition to requiring statistics of its majors, offers both a 2-credit economic statistics course and a 4-credit econometrics course.

Almost all Grinnell students complete some coursework in abstract or quantitative reasoning; recent figures show that 96% of students graduate with at least one course in that area. Fifty-four percent take three or more such courses. Eighty-six percent complete at least one course that deals with the scientific method. Regarding statistics, figures from 2004-2005 report that 249 Grinnell students (approximately 17% of the student body) enrolled in either Math 115 or Math 209 that year. Enrollment had been steady for some time, but in 2004/2005 increased a bit (approximately 3%) from the previous year.

At another level, a variety of substantive courses in the Science and Social Studies Divisions at Grinnell include quantitative reasoning components. These take a variety of forms, but include exploration of secondary research that involves quantitative analysis, as well as data collection and analysis in the courses themselves or in labs connected to courses. Increasingly, Grinnell students are conducting Mentored Advanced Projects (MAPs). A common model for MAPs is for students to conduct their own research projects, many of which involve quantitative reasoning skills.

Staffing: The Math/CS Department has two statisticians, one of whom occupies a new position that includes a course release for statistical consulting for faculty and advanced students. The statisticians staff approximately four sections of statistics per year. Approximately three or four sections each year of Math 115 are taught by faculty from other departments. The goal of the college is to provide staffing from the ranks of permanent faculty; indeed this year the college has met this goal. However, it is quite common to staff the statistics courses with faculty in term position. And, though rare, sometimes individuals are hired solely to teach one or two sections of the course.

Support: Grinnell's "Math Lab" was founded in 1976-1977. Administered by a full-time, permanent director, the Math Lab offers for-credit instruction as well as tutoring. In addition to the director, the Math Lab is staffed by a cadre of student assistants. A "Science Lab," also staffed by a full-time director, offers supplemental instruction for students in first-year science courses. The college also has three full-time Curricular Technology Support (CTS) personnel. The CTS personnel offer assistance to faculty in a utilizing technology in their teaching, including technology that facilitates instruction in quantitative reasoning.

- Barbara Trish

Lawrence University, Appleton, Wisconsin

This page http://www.lawrence.edu/dept/faculty_dean/ger/ provides links to the description of the general education requirements at Lawrence University (GERs), which includes a requirement in "Mathematical Reasoning or Quantitative Analysis," and to the forms that faculty fill out if they are proposing that a course fulfill our quantitative requirement.

And a direct link to the description of the GERs is:
http://www.lawrence.edu/dept/faculty_dean/ger/bager.shtml.

The following link is a MAA Article
(http://apps.carleton.edu/collab/quantitative_conference/assets/MAA_QL_paper.pdf)

about Lawrence University's quantitative program.

-Beth Haines

Macalester College, St. Paul, Minnesota

The faculty at Macalester voted last spring to institute a quantitative reasoning graduation requirement, but left the details of the requirement to be worked out by a group of faculty during the summer. The proposal from that group is available at:

<http://www.macalester.edu/curricularrenewal/documents/QuantThink.pdf>

The plan is to discuss the proposal among the faculty as a whole this semester, with a decision about whether to adopt it by the end of the semester.

-Danny Kaplan

Ripon College, Ripon, Wisconsin

There is no quantitative requirement in the current curriculum.

Courses in the Department of Mathematics and Computer Science satisfy various requirements of specific programs, but there is no college-wide requirement that is satisfied by any of our courses.

The departmental blurb is at: <http://www.ripon.edu/academics/macs/>

-Diane Beres

Saint Olaf College, Northfield, Minnesota

Current general education requirements: One course in mathematical reasoning is one of the requirements in our general education program. Instructors or departments that want to offer a course satisfying the mathematical reasoning requirement must receive the approval of the General Education Committee. At the time the current general education program was adopted, guidelines for each requirement were developed. The guidelines for a course in mathematical reasoning can be found at:

<http://www.stolaf.edu/committees/gec/genedrequirements/math.html>.

While other departments are free to propose mathematical reasoning courses, this has not happened. All courses that currently satisfy the mathematical reasoning requirement are offered by the Mathematics, Statistics, and Computer Science Department. For this year these are: Principles of Computer Science, Principles of Statistics, Statistics for the Sciences (prerequisite of calculus I), Gateways to Mathematics, Geometric Patterns in Islamic Culture (developed by a faculty member who led St. Olaf's study abroad program to the Middle East), Principles of Mathematics, Calculus I, Calculus II, and Elementary Linear Algebra. Students who receive a score of 4 or 5 on either AP Calculus exam or the AP Statistics exam may use AP credit to satisfy the mathematical reasoning requirement.

Gateways to Mathematics and Principles of Mathematics are both math for liberal arts courses. At the time the current general education requirements were adopted, we designed the two courses to serve different audiences. The target audience for Gateways was first year students who did not want to take calculus or statistics; the target audience for Principles was upperclass students who had little interest in mathematics. Gateways was to focus on one topic, while Principles was to be more of a math sampler, with some attention to the history of mathematics. In practice, this attempt to segregate the audience has not worked well. Many semesters only one or the other is offered, and students who want to take math that semester will sign up for whatever is available. Also, since the department has never developed a syllabus for the courses, and they have often been assigned to temporary faculty, the content of both courses has varied considerably. At this point, the content of both courses could best be described as instructor's choice. I am currently teaching Gateways using *Excursions in Modern Mathematics* by Tannenbaum for the text. Topics in the past have included mathematics of games, cryptography, and origami.

Proposed changes in general education requirement: A committee that reviewed the general education program in 2004 posed the following questions: Should the "mathematical reasoning" requirement be retained or should it be replaced with a quantitative literacy requirement? Could mathematical study occur more broadly across the curriculum?

The Mathematics, Statistics, and Computer Science Department (MSCS) is currently working on a revision of the requirement that we will recommend to the campus committee overseeing changes to the general education program. Our current draft identifies two possible foci for a course: abstract modeling (as in computer science or calculus) or quantitative reasoning with data (statistics). We do not believe that the faculty would approve a requirement for more than one course in quantitative or mathematical reasoning. Faculty action on any change in the requirement should take place this year. While we have had input from a few faculty outside the MSCS Department, it is too early to tell if a significant revision in the requirement will occur.

Quantitative reasoning at a more advanced level: Several majors require or recommend courses in mathematics or statistics. A quarter credit course called Quantitative Methods in Ecology and Evolution may be taken in conjunction with biology courses in ecology and evolution. Currently taught by a faculty member with a specialty in mathematical biology, this course focuses on mathematical models related to the biological topics being studied. Approximately fifteen to twenty students per year (about half of whom are math majors) complete a four course statistics concentration.

Under the auspices of the Center for Interdisciplinary Research statistics students engage in collaborative research projects with faculty and students from a variety of disciplines. For more on this program see <http://www.stolaf.edu/academics/cir/>.

Contact: If you have questions about any of the above, please contact Kay Smith, Associate Professor of Mathematics, at smithk@stolaf.edu or at 507-646-3784.

- Kay Smith