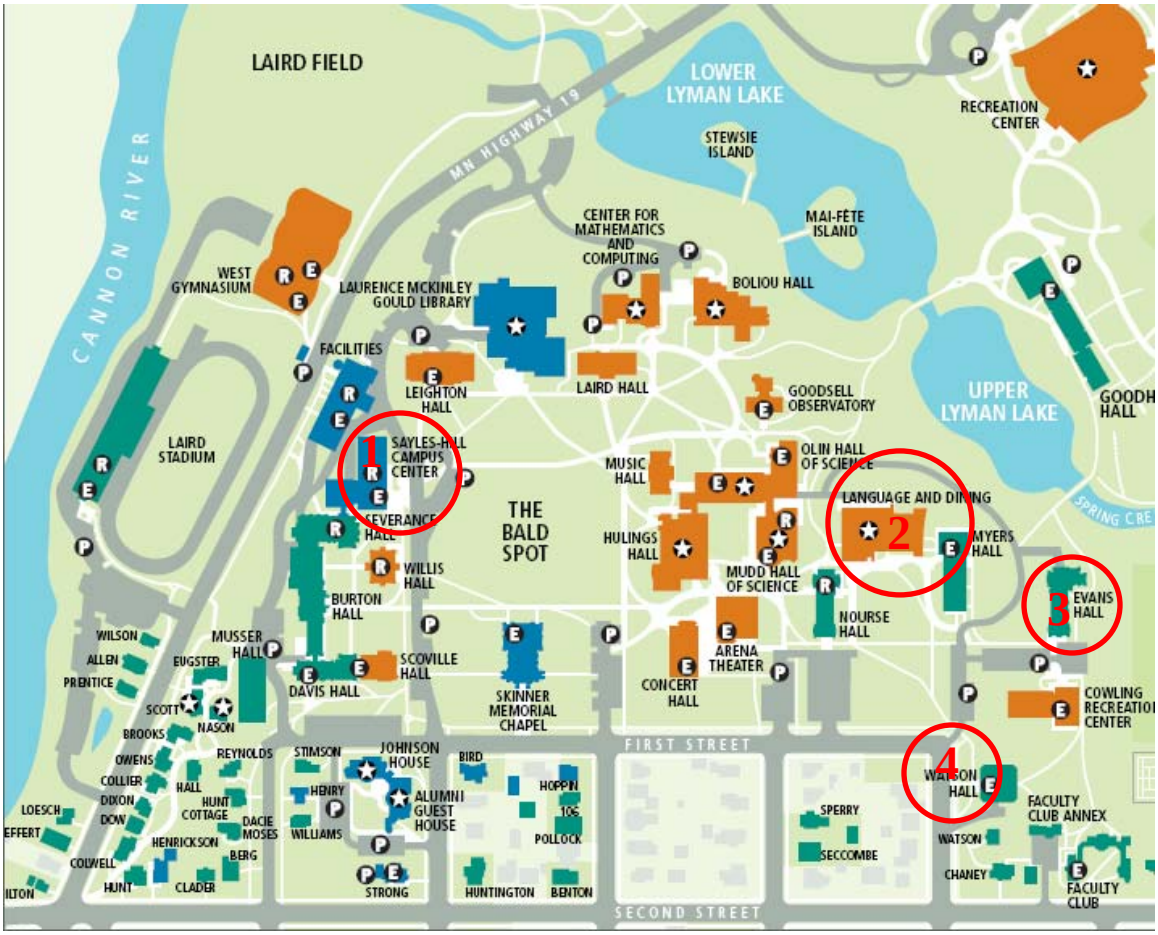
The QuIRK Initiative & Project Kaleidoscope

Quantifying Quantitative Reasoning in Undergraduate Education: Alternative Strategies for the Assessment of Quantitative Reasoning

Carleton College
October 10 - 12, 2008

QuIRK Carleton Quantitative Inquiry, Reasoning, & Knowledge Initiative



1: Sayles-Hill Campus Center
2: Language and Dining Center (LDC)
3: Evans Hall
4: Shuttle Bus Pick-up/Drop-off

October 10, 2008

Dear PKAL/QuIRK workshop participants:

Welcome! We are very happy to host you for what we hope will be a transformative weekend for 24 campuses from across the United States and Australia.

It wasn't even a decade ago that the *National Council on Education and the Disciplines* concluded that quantitative reasoning (QR) is "largely absent from our current systems of assessment and accountability." Fortunately, the QR community has been very busy in recent years attempting to fill this gap. The facilitators who have agreed to work with you have been on the front lines of this effort. As you will learn, our story is not one of continual and speedy progress. But collectively we're making progress and we hope our experiences can help you move forward at your own institution.

Institutional change is hard work. I applaud you for the commitment you have already shown as you prepare for this workshop. When you leave the workshop, you will be further equipped with a clear and specific plan for action to implement when you return to your campuses. With help from the National Numeracy Network, we intend to support you in the hard work that will surely accompany your work.

A workshop of this size cannot be organized without significant help. I would like to thank the National Science Foundation and Carleton's Dean of the College for financial support, Project Kaleidoscope for help designing the weekend, and, above all, the gracious and generous contributions of all of the facilitators without whom we would not have a workshop to present.

Good luck with your work!

Sincerely,

Nathan D. Grawe
Director, QuIRK Initiative

Summary Agenda

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Friday, October 10, 2008

12:30 – 3:15 p.m.	**WORKSHOP REGISTRATION** *(Registration table in front of Carleton Bookstore)*	*Sayles-Hill Great Space*
12:30 – 3:00 p.m.	*Facilitator/Presenter Luncheon Meeting*	*Sevy Meeting Room*
3:30 p.m.	**WELCOME & PLENARY SESSION I** *The Quantitatively Reasoned Life*	*Evans Dining*
5:15 p.m.	**CLUSTER GROUP MEETINGS** *Exploring Goals*	*Listed with assignments*
6:30 p.m.	**DINNER & PLENARY SESSION II** *Use, Misuse, and Missed Use of Quantitative Reasoning in Student Writing*	*Evans Dining*
8:30 p.m.	**BUSES DEPART FROM CAMPUS TO HOTELS**	

Saturday, October 11, 2008

7:45 a.m.	**BUSES DEPART FROM HOTELS TO CAMPUS**	
8:30 a.m.	**BREAKFAST** *Birds-of-a-feather discussions*	*Evans Dining*
9:00 a.m.	**BREAKOUT SESSION I**	
	A. The Wellesley College Story	*LDC 302*
	B. The James Madison University Story	*LDC 330*
	C. The Augsburg College Story	*LDC 335*
	D. The Macalester College Story	*LDC 345*
10:10 a.m.	**CLUSTER GROUP MEETINGS** *Next Steps— Strategies and Actions*	*Listed with Assignments*
11:45 a.m.	**LUNCH & PLENARY SESSION III** *Challenges of QR Assessment*	*Evans Dining*
1:15 p.m.	**BREAKOUT SESSION II**	
	A. The University of Arkansas Story	*LDC 330*
	B. The Alverno College Story	*LDC 335*
	C. The Carleton College Story	*LDC 345*

2:30 p.m.	**BREAKOUT SESSION III**	
	A. Grant Sources and Strategies	*LDC 302*
	B. Creating Enduring Resources	*LDC 330*
	C. Generating Interdisciplinary Institutional Buy-In	*LDC 335*
	D. Student Support Services	*LDC 345*
3:40 p.m.	**TIME FOR RELAXATION AND PERSONAL REFLECTION**	
4:40 p.m.	**CAMPUS TEAM MEETINGS** *(including boxed dinners)*	*Evans Dining*
6:00 p.m.	**BUSES DEPART FROM CAMPUS FOR GUTHRIE THEATER** *A View from the Bridge by Arthur Miller*	

Sunday, October 12, 2008

7:45 a.m.	**BUSES DEPART FROM HOTELS TO CAMPUS**	
8:30 a.m.	**BREAKFAST AND TEAM MEETINGS** *Finalize Action Plans*	*Evans Dining*
9:45 a.m.	**PLENARY SESSION IV** *Team Reports & Open Q&A*	*Evans Dining*
11:30 a.m.	**LUNCH AND PLENARY SESSION V** *Building a QR Community: The Future of the National Numeracy Network*	*Evans Dining*
12:30 p.m.	**BUS DEPARTS FROM CAMPUS TO AIRPORT**	

The ability to apply quantitative methods to real-world problems requires a facility and an insight and intuition that can be developed only through repeated practice. Thus quantitative material needs to permeate the curriculum, not only in the sciences but also in the social sciences and, in appropriate cases, in the humanities, so that students have opportunities to practice their skills and see how useful they can be in understanding a wide range of problems.

— Derek Bok, Our Underachieving Colleges

Welcome & Plenary Session I

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THE QUANTITATIVELY REASONED LIFE

Time: 3:30 – 5:00 p.m. Date: Friday, October 10, 2008 Location: Evans Dining

QuIRK is an innovative project intended to help Carleton and other institutions of higher education better prepare students to evaluate and use quantitative evidence in their future roles as citizens, consumers, professionals, business people, and government leaders. The focus of the project is on how quantitative reasoning (QR) is used in the development, evaluation, and presentation of principled argument.

QuIRK's program reflects a circular model of pedagogical reform. Through annual assessment, we evaluate samples of student writing for evidence of QR. (At Carleton, these samples are drawn from the sophomore writing portfolio. At institutions without portfolios, other methods of obtaining student writing samples have been developed.) Assessment findings inform a professional development curriculum for faculty workshops and brown-bag discussions. Equipped with a deeper knowledge of student needs and tools to meet them, faculty are encouraged to engage in curricular reform, through course revision and new course design. The circuit is completed with subsequent assessment that evaluates the effectiveness of prior reform efforts.

— http://serc.carleton.edu/quirk/About_QuIRK.html

Welcome:

- Nathan D. Grawe
  Associate Professor of Economics & Director of QuIRK
  Carleton College
- H. Scott Bierman
  Dean of the College
  Carleton College

Facilitators:

- Bernard L. Madison
  Professor of Mathematics
  University of Arkansas
- Lynn A. Steen
  Special Assistant to the Provost & Professor of Mathematics
  St. Olaf College

After almost two decades, the quantitative reasoning movement is still largely indebted to the contributions of Lynn Steen, author and editor or numerous books including *Achieving Quantitative Literacy*, and *Mathematics and Democracy: The Case for Quantitative Literacy*. Today a new generation of leaders are building on that work. One of those leaders is Bernie Madison, Emeritus President of the National Numeracy Network and AP Calculus Chief Reader (among other leadership positions). In the opening plenary, Lynn will interview Bernie about the nature of quantitative reasoning (QR), the present state of the QR movement, and its future.

Welcome & Plenary Session I

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THE QUANTITATIVELY REASONED LIFE

Time: 3:30 – 5:00 p.m. Date: Friday, October 10, 2008 Location: Evans Dining

Notes:

Best Idea:

Over the past several years, the work of PKAL has been enriched and extended through collaborative efforts with a wide range of "near-peer" networks, recognizing that collaborations are powerful "agents of change." What we are learning validates research on dissemination: how ideas evolve, emerge and are enhanced when like-minded colleagues pursue a common vision.

This research also speaks directly to the impact of "near-peers" on influencing and persuading others to explore, adapt, and assess approaches having demonstrable impact on strengthening STEM learning at all levels. The range and diversity of networks and collaborations now making a difference at the undergraduate level is remarkable; dissolving boundaries of discipline, geography, spheres of responsibility, and career stage as they work to transform the undergraduate STEM learning environment in this country.

— http://www.pkal.org/documents/NetworksAndCollaborations.cfm

Cluster Group Meetings

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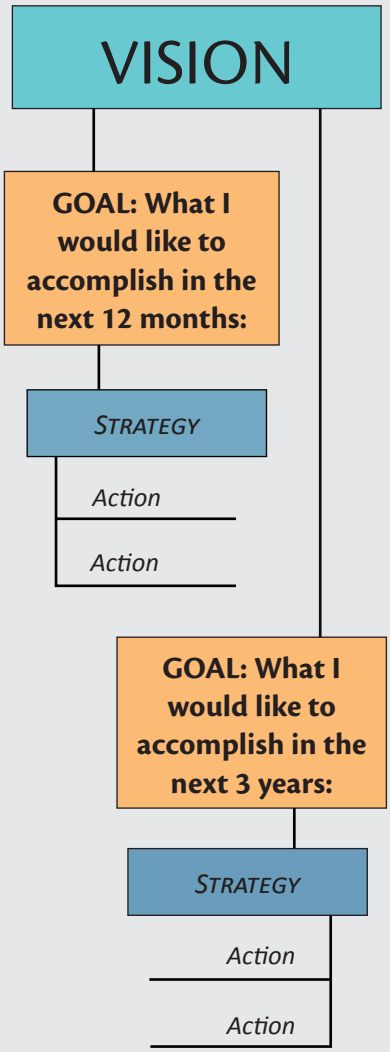
EXPLORING GOALS

Time: 5:15 – 6:15 p.m. Date: Friday, October 10, 2008 Location: Listed with Assignments

The PKAL Planning Process



Group	Facilitators	Location
1	Rebecca Hartzler and Bernie Madison	LDC 205
2	Neil Lutsky and Sue Mente	LDC 302
3	Caren Diefenderfer and David Bressoud	LDC 330
4	Milo Schield and Corri Taylor	LDC 335
5	Nathan Grawe and Donna Sundre	LDC 345
6	Len Vacher and Linda Kirstein	LDC 202

Participants/teams are asked to develop and list plans for action upon return to their campuses. Plans should be prepared on the poster material available. Reporting out of agendas for action is on Sunday morning.

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Cluster Group Meetings

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EXPLORING GOALS

Time: 5:15 – 6:15 p.m. Date: Friday, October 10, 2008 Location: Listed with Assignments

Goal Draft #1

Goal Draft #2

Goal Draft #3

...it is a characteristic of science that it is a cooperative effort. It is not simply the speculation of some sage or scholar in the privacy of his study. Science of any kind is a matter of teamwork between specialists who have soaked themselves in their subject, who live together, who criticize one another's ideas, each of whom makes an individual, although quite often imperceptible, contribution to the totality of knowledge and understanding.

Very occasionally an outstanding thinker may emerge who has insights which will short circuit the patient studies of the professionals. But such outstanding thinkers are unusual. So failing the great mind, science has to be developed by the interplay of average minds, one hopes, rather above average. It progresses by dialogue and teamwork.

— Michael Howard, "Military Science in an Age of Peace." *The Journal of the Royal United Services Institute for Defense Studies*, March 1974.

Dinner & Plenary Session II

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USE, MISUSE, AND MISSED USE OF QUANTITATIVE REASONING IN STUDENT WRITING

Time: 6:30 – 8:15 p.m. Date: Friday, October 10, 2008 Location: Evans Dining

Learning Goals

Our overarching goal is to enable students to establish a foundation of effective quantitative reasoning and problem solving strategies that:
1) is needed for the completion of their degree program of study
2) will remain with them throughout life and
3) is relevant in life activities of most citizens.

The competency will teach students using situations that appear in common life the following abilities:

1. The ability to: a) represent quantitative information symbolically visually numerically and verbally. b) interpret graphs tables and schematics and draw inferences from them. c) use number sense arithmetic operations and technology to describe analyze and assess real-world problems. d) utilize measurement to describe geometric physical and other quantities (such as weight area volume time) for precision and accuracy. e) apply basic statistical concepts and basic data analysis to describe and interpret issues and draw valid conclusions. f) analyze and assess issues involving risk and chance using probability concepts.

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Facilitators:

❖ Nathan D. Grawe
Associate Professor of Economics
Carleton College

"Numbers [are] the principal language of public argument."
— Website for the BBC Radio 4 program *More or Less*

One way to think of quantitative reasoning is the habit of mind to consider the power and limitations of numerical evidence in addressing personal, professional, and public problems. Clearly, this demands a basic skill set. But to fully realize this vision requires much more. First, students must transfer these skills into the particular context in question. While this may seem trivially obvious, research on how students learn suggests this is very difficult. Second, because few problems are addressed in solitude, students must be able to communicate effectively their line of quantitative argument.

These QR communication skills are closely related to general writing and argumentation skills. And yet, the use of numbers in charts, tables, and text raises unique challenges as well. Finally, even students with strong QR skills—students who have the mathematical and rhetorical skill to argue for a context-rich point of view grounded on numerical evidence—may lack the instinct to draw on these skills. As the National Council on Education and the Disciplines puts it, students "need a predisposition to look at the world through mathematical eyes."

So where could we look for evidence of whether students have acquired this habit of mind and are effectively applying it to contextualize problems? Carleton College's Quantitative Inquiry, Reasoning, and Knowledge (QuIRK) initiative has been examining papers students have written for classes across the college to learn how students use, mis-use, and fail to use quantitative reasoning in their arguments.

In this session, participants will read several excerpts of student papers that exemplify patterns seen at Carleton. Tables will discuss the relevance of these patterns to student arguments on their campuses. Carleton will briefly share some of the lessons we are learning through our writing-based assessment. Key among these have been insights in the ways students use (and don't use!) quantitative reasoning in a "peripheral" way. This use is eloquently described by Jane Miller in *The Chicago Guide to Writing about Numbers*: "Even for works that are not inherently quantitative, one or two numeric facts can help convey the importance or context of your topic."

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Dinner & Plenary Session II

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USE, MISUSE, AND MISSED USE OF QUANTITATIVE REASONING IN STUDENT WRITING

Time: 6:30 – 8:15 p.m. Date: Friday, October 10, 2008 Location: Evans Dining

Notes:

Best Idea:

8:30 p.m. Buses depart from campus to hotels

d) utilize measurement to describe geometric physical and other quantities (such as weight area volume time) for precision and accuracy. e) apply basic statistical concepts and basic data analysis to describe and interpret issues and draw valid conclusions. f) analyze and assess issues involving risk and chance using probability concepts.

2. The ability to apply QR skills and appropriate habits of mind to: a) formulate and analyze models to make predictions draw conclusions and judge the reasonableness of the results. b) estimate and check answers to quantitative problems in order to determine reasonableness identify alternatives and select optimal results. c) evaluate and create logical and quantitative arguments. d) communicate mathematical and statistical ideas to others.

— from Team Application

Breakfast

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BIRDS-OF-A-FEATHER DISCUSSIONS

Time: 8:30 – 9:00 a.m. Date: Saturday, October 11, 2008 Location: Evans Dining

Learning Goals

The faculty adopted a set of guidelines for Quantitative Reasoning Courses which emphasize that quantitative reasoning should be taught across the curriculum and should combine an emphasis on quantitive reasoning with mastery of the course content and should stress the development and application of quantitative reasoning skills which are appropriate to the discipline.

Manipulation of data or symbols alone does not qualify a course as a QR course. As the guidelines state courses require competence in (1) independent quantitative reasoning and problem-solving (2) interpretation and decision-making based upon quantitative information and (3) the critical assessment of quantitative models. Evaluation should include assessment of these three abilities. The program (and especially the workshop) also stress active learning pedagogies and an inclusive attitude toward student development. These were innovative ideas when the competence requirements were adopted and the workshops continue to serve as a means to emphasize their importance.

— from Team Application

Time to talk about issues of import to:

- Deans (Tables 1, 2)
- Writing Program Directors (Tables 3, 4)
- QR Program Directors/representatives (Tables 5, 6, 7, 8, 9, 10)
- Assessment office representatives (Table 11)
- Faculty- Science (Tables 12, 13, 14, 15, 16)
- Faculty- Liberal Arts (Tables 17, 18, 19)

Breakfast

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BIRDS-OF-A-FEATHER DISCUSSIONS

Time: 8:30 – 9:00 a.m. Date: Saturday, October 11, 2008 Location: Evans Dining

Notes:

Best Idea:

Campus Culture

The main challenge we face is a lack of consensus regarding assessment itself. Many of the recent faculty discussions concerning assessment reveal concerns about a lack of clarity in what is being assessed. In addition there are concerns about the ability to make meaningful conclusions when assessing courses from disparate disciplines.

As we have just completed a curricular revision this is a perfect time to implement a meaningful assessment system. While we have not yet reached agreement concerning how to assess most of the faculty agree that we need to assess our general education including QR courses. Finally as we are in the process of preparing for an accreditation visit in the fall many see this as an opportunity and as motivation to have a plan in place within the next year.

— from Team Application

Breakout Session I-A

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THE WELLESLEY COLLEGE STORY

Time: 9:00 – 10:00 a.m. Date: Saturday, October 11, 2008 Location: LDC 302

Learning Goals

Our short range plans are focused on the Faculty Learning Community. Each of the members of this community have the goal of changing at least one course that they teach in a way that incorporates quantitative literacy in a more substantial way.

Our longer range goal include changing the undergraduate general education requirement to incorporate quantitative resaoning across the curriculum. (Please note that this does not mean that we will require another statistics course but that there will be courses in all majors that include quantitative reasoning.) Our long range goal is to have a center for quantitative literacy (or reasoning) modeled after our existing center for writing.

— from Team Application

Facilitator:

❖ Corrine Taylor
Director of Quantitative Reasoning Program
Wellesley College

Beginning with those who matriculated in Fall 1997, Wellesley College students must satisfy a two-part quantitative reasoning requirement: a "basic skills" requirement and a "QR overlay" requirement. A student satisfies the basic skills component either by passing an 18 question, open-response QR assessment upon entering the College or by passing the first year course "Introduction to Quantitative Reasoning." The course, taken by approximately 8 percent of each first year class, presents important QR content (including logic, numeracy, algebra, linear and exponential modeling, graphing, geometry, and basic probability and statistics) in a variety of authentic contexts, such as medical decision-making and personal finance. Students must satisfy the QR basic skills requirement before enrolling in quantitative courses including most science and economics courses.

Before graduating, each student must also pass a course that is designated as a "QR overlay course." These courses emphasize statistical analysis and interpretation of data in a specific discipline. Some overlay courses are semester-long statistics classes (e.g., in economics and sociology, psychology, political science, and mathematics). Others are laboratory science classes in which students collect and analyze data.

This session will recap the story of how Wellesley College developed this two-part requirement, will describe in more detail how the program operates, and moreover, will provide findings on the effectiveness of the program. Effectiveness is measured in several ways including: students' attitudes pre- and post- taking "Introduction to Quantitative Reasoning"; students' growth in knowledge and skills based on pre- and post-assessments; and students' course-taking behavior. New initiatives in assessing students' QR skills will also be described.

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Breakout Session I-B

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THE JAMES MADISON UNIVERSITY STORY

Time: 9:00 – 10:00 a.m. Date: Saturday, October 11, 2008 Location: LDC 330

Facilitator:

❖ Donna L. Sundre
Executive Director of Center for Assessment & Research Studies
Professor of Psychology
James Madison University

This session will provide the background and the 'journey' of how the James Madison Quantitative Reasoning instrument was developed. This journey spans over a decade of slow and careful work with a highly collaborative team of subject matter experts who teach the related general education courses. Working with their assessment consultant from the Center for Assessment and Research Studies, we continuously monitored and revised the instrument. Through our continued work the student learning objectives the instrument was designed to measure were consolidated.

We are currently using our 9th version of the instrument (QR-9). Our story will describe how we have been using the instrument to inform our curriculum, provide accountability evidence, and improve instruction. The QR-9 is a foci for an NSF grant designed to enhance the assessment of quantitative and scientific reasoning. Four partner institutions with very distinct missions and serving diverse populations have used the instrument successfully over the last year. They are continuing their data collection this academic year. The progress from these institutions will be reported as well.

Campus Culture

Because we are currently evaluating the new General Education curriculum we are uncertain of what the final General Education model will be. If the model remains more distributive in nature the integration of QR into the curriculum beyond those areas traditionally quantitative is left to the individual instructor missing an important opportunity to expose students to QR within other disciplines.

In addition assessment also becomes a challenge because students will take courses exposing them to QR at different points in their academic career and finding a common point for assessment is difficult. If however we adopt a more interdisciplinary model another challenge in extending QR on our campus is faculty experience with QR.

While our faculty have had conversations on QR in the past we have a cohort of new faculty who were not part of that discussion. There will likely be a need for professional development for faculty who do not have experience in teaching developing assignments or assessing QR. It is our hope that we can begin this process by attending the PKAL/QuIRK workshop.

— from Team Application

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Breakout Session I-C

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THE AUGSBURG COLLEGE STORY

Time: 9:00 – 10:00 a.m. Date: Saturday, October 11, 2008 Location: LDC 335

Campus Culture

While improving students quantitative reasoning is not in principle controversial the impact that a new academic initiative could have on existing programs is bound to be controversial at least for some members of the college community. In particular it is not clear that everyone will consider an ethos of quantitative literacy to be as important as an ethos of writing development and support.

Faculty development programs are presented by members of the Center for Teaching Learning and Research along with other faculty and staff and already receive strong support. This will be an important resource as we consider the possibility of QR in the disciplines courses and other approaches to quantitative learning and assessment.

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Facilitators:

❖ Marc D. Isaacson
Assistant Professor of Business Administration
Augsburg College
❖ Milo Schield
Professor of Business Administration
Director of the W. M. Keck Statistical Literacy
Augsburg College

This session presents two basic QL assessments being piloted at Augsburg College.

(1) A 25 question QL assessment that tests a student's ability to read data presented in a two-page Quick Facts brochure of U.S. wildlife hunters and observers published by the US government for the general public.

(2) A 69 question 2008 Statistical Literacy assessment that tests a broader range of student skills. This assessment involves a variety of graphs, tables and quantitative statements all of which relate to numerical information found in the everyday news.

Both approaches are designed to assess basic skills in reading and understanding numbers in context. Student results are presented for both instruments.

These assessments are part of the W. M. Keck Statistical Literacy Project. They are grounded in literacy: the ability to read and write ordinary English statements and to interpret and create simple graphs and tables. They focus on those quantities encountered in the everyday news: counts, totals ranks, percentiles, percentages, percentage change, rates, ratios, means, medians and margin of error. They focus on how numbers are influenced by human choices: choices in defining categories and measurements and choices in presenting the results. They focus on context: what was and was not taken into account.

Session Resources:

Schield, Milo (2004). "Statistical Literacy and the Liberal Arts at Augsburg College." *Peer Review*, American Association of Colleges and Universities.Draft of paper at www.StatLit.org/pdf/2004SchieldAACU.pdf

Schield, Milo (2007). "Quantitative Literacy Core Concepts." Invited talk at Carleton College on Quantitative Literacy. Slides at www.StatLit.org/pdf/2007SchieldCarleton6up.pdf

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Breakout Session I-D

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THE MACALESTER COLLEGE STORY

Time: 9:00 – 10:00 a.m. Date: Saturday, October 11, 2008 Location: LDC 345

Facilitators:

❖ David M. Bressoud
Professor of Mathematics
Macalester College

In November 2005, the faculty of Macalester College voted to institute a graduation requirement in quantitative thinking (QT) that is truly interdisciplinary. It currently draws on courses from thirteen departments including Anthropology, Economics, Geography, Political Science, Theater, Mathematics, Environmental Science, and Geology. This session will briefly review the story of how we brought this program into being, describe what the program looks like today, and provide opportunities for discussion around the four stages of the process at Macalester:

- Planning
- Experimentation and Building Faculty Buy-in
- Getting the Program Accepted
- Keeping it Strong.

In addition a pilot program of Portfolio Assessment of student writing in the disciplines is underway for a selection of students from the class of 2010. Funded through a Teagle Foundation Award the program will allow a more comprehensive look at each of the students in the pilot including interviews and other institutional data. Each such student portfolio will be examined at three critical stages in a students career: as a first year student making the transition.

— from Team Application

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Breakout Session I

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NOTES

Time: 9:00 – 10:00 a.m. Date: Saturday, October 11, 2008

Campus Culture

Revision of Core Curriculum plans to switch to an enduring questions model for the first level and incorporate an interdisciplinary minor for every student at the second level. This is a broad opportunity to focus on student learning outcomes and incorporate current best practices in developing implementing and assessing quantitative reasoning across the curriculum We have an emphasis on assessment as part of Middle States accreditation.

We have an Office of Institutional Research and are looking at instruments to use in assessing the core. We have an active successful Writing Across the Curriculum Program as part of the current core and are discussing how to integrate it throughout the new core model. It will be natural to discuss infusing quantitative reasoning throughout the core as well as to assess quantitative reasoning through student writing.

— from Team Application

Notes:

Best Idea:

Cluster Group Meetings

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NEXT STEPS— STRATEGIES AND ACTIONS

Time: 10:10 – 11:30 a.m. Date: Saturday, October 11, 2008 Location: Listed with Assignments

Group	Facilitators	Location
1	Rebecca Hartzler and Bernie Madison	LDC 205
2	Neil Lutsky and Sue Mente	LDC 302
3	Caren Diefenderfer and David Bressoud	LDC 330
4	Milo Schield and Corri Taylor	LDC 335
5	Nathan Grawe and Donna Sundre	LDC 345
6	Len Vacher and Linda Kirstein	LDC 202

Notes:

Campus Culture

I anticipate challenges in recruiting interested faculty because they either don't think it's important or are already pursuing their own efforts; and in interesting university administrators in making this a campus-wide issue because they don't know what I'm talking about and don't see why it's important. I also anticipate difficulty in getting this addressed at a campus level because there is no requirement like a sophomore portfolio that crosses all departments. Because we're such a diverse university if it gets addressed at a university-wide level probably each college would have to devise its own approach.

— from Team Application

Lunch & Plenary Session III

CHALLENGES OF QUANTITATIVE REASONING ASSESSMENT

Time: 11:45 a.m. – 1:00 p.m. Date: Saturday, October 11, 2008 Location: Evans Dining

Barriers

The newly adopted curriculum is intended to encourage QR and oral communication while providing enough flexibility for faculty to incorporate skills that work well in their classes. One concern is that we will not branch out far enough from where we are now â€“ that the math and science courses and the social science courses that focus on data analysis will incorporate QR and the other social science courses and the humanities courses will incorporate oral communication.

But this will not provide the integration and contextualized learning that we want to accomplish with our new curriculum. We need to work to incorporate both QR and oral communication more broadly across the curriculum so that students see them not as compartmentalized skills but as truly permeating their intellectual experience.

Facilitator:

❖ Donna L. Sundre
Executive Director of Center for Assessment & Research Studies
Professor of Psychology
James Madison University

This session will highlight many of the challenges associated with assessment in general and quantitative reasoning more specifically. It is hoped that participants will benefit from the triumphs and disappointments experienced over many years of assessment practice. Donna has spent over 20 years working with faculty across her campus developing program goals and objectives and instruments to assess these goals and objectives with confidence. We have learned from our many trials. There are many strategies that work, and of course we have discovered several that do not.

Participants will conduct a small-group thought experiment to help develop a construct. We will review an easily generalized assessment model and apply this to our thought experiment. Donna will provide some guidelines for success and some warnings of all too common pitfalls. This is challenging work, and if we do not carefully plan for these challenges, we will have wasted our time, energy, and dear resources. When this happens, faculty will legitimately claim that "Assessment was a waste of time."

The mantra for the session might just be:

If we want to measure quantitative and scientific reasoning…we're going to have to use some!

Lunch & Plenary Session III

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CHALLENGES OF QUANTITATIVE REASONING ASSESSMENT

Time: 11:45 a.m. – 1:00 p.m. Date: Saturday, October 11, 2008 Location: Evans Dining

Notes:

Best Idea:

Another concern is our previous lack of QR programming. Writing across the curriculum has been widely discussed on campus and there has been substantial faculty development for it but QR has been seen as the purview of the math and science departments. Faculty in other disciplines who may be receptive to incorporating QR into their classes have had no formal support for developing or trying related ideas.

Furthermore we don't know yet what support to provide; this is uncharted territory for our faculty development team as well. Much progress is needed in this area but we hope to build on what we learn from this workshop and other sources to provide major faculty development efforts in support of QR over the next few years as we implement the new curriculum.

— from Team Application

Breakout Session II-A

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THE UNIVERSITY OF ARKANSAS STORY

Time: 1:15 – 2:15 p.m. Date: Saturday, October 11, 2008 Location: LDC 330

Learning Goals

As we prepare to establish a quantitative skills requirement this fall we are in the process of identifying existing courses that are quantitatively intense. By quantitatively intense we mean courses that devote significant amounts of class time to some of the following areas:

(a) elementary statistical reasoning;
(b) working with manipulating and judging the reliability of quantitative data;
(c) generating and understanding graphical relationships;
(d) representing theoretical ideas and empirical phenomena numerically; and
(e) determining numerical predictions of natural or social systems. We acknowledge that these course characteristics are not learning outcomes. We are in the process of shaping the right learning outcomes for our students.

— from Team Application

Facilitator:

❖ Bernard L. Madison
Professor of Mathematics
University of Arkansas

We have been working on a quantitative reasoning course based on media articles for three years. This session will focus on that course and how it works.

We have developed a casebook of case studies of media articles that we use in the course. The casebook is in its first "pre-book" stage.

A copy of the casebook will be provided for each team in the workshop. (We do not anticipate this to become a commercial product, so this is not a promotion.)

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Breakout Session II-B

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THE ALVERNO COLLEGE STORY

Time: 1:15 – 2:15 p.m. Date: Saturday, October 11, 2008 Location: LDC 335

Facilitator:

❖ Suzanne Mente
Assistant Director of Instructional Services
& Quantitative Literacy Coordinator
Alverno College

Alverno College is a four–year private, college for women in Milwaukee, Wisconsin. Our enrollment is approximately 2300 students with 35% minority and 74% first generation college students. Alverno has an ability based curriculum and follows an assessment model. These characteristics presented both advantages and challenges when implementing our quantitative literacy in the disciplines program. In this workshop, participants will trace the movement from a quantitative literacy graduation requirement consisting of a one credit freshman level course to our current status that requires students to demonstrate quantitative literacy in their discipline courses. The particular focus of the workshop will be creating faculty buy–in and support for a QL across the curriculum program.

Participants will begin by exploring ways to lay ground work with faculty and showing need for QL across the curriculum. We will review materials used to broaden faculty's perception of quantitative literacy and then discuss their rationale and effectiveness. We will also consider survey possibilities and other ways of gathering baseline information.

Success of a QL across the curriculum program depends greatly on faculty buy – in. Participants will discuss trials, tribulations and successful strategies used to bring faculty aboard. These include acknowledging and respecting some faculty's own insecurities about mathematics (and ways to help them), the arduous process of defining quantitative literacy learning goals in terms that would be meaningful in all disciplines, and helping faculty to see the QL opportunities in their own courses.

Finally, participants will discuss how to sustain a program after the initial excitement wears off. This includes ongoing workshops, creating resource materials/ clearinghouse, training for new faculty, and monitoring the program for consistent levels of expectation.

In addition to exploring materials used at Alverno College, participants will have opportunity to brainstorm strategies and share ideas that would be effective at their own institutions.

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Notes: Page 23

Learning Goals

To the learning goals stated in QUIRK's example response I would add the more nebulous but essential disposition or habit of mind to use QUIRK's nine outcomes naturally throughout one's encounters with the world in classes at this institution and perhaps more importantly in the wide world beyond.

A quantitatively literate person looks at the numbers: in The New York Times in an analysis of costs of the First World War in population estimates in the Americas before 1492 as a source of information as rich as the text. This is the issue of "transferability" that plagues every educator. We have tried to instill this habit by making the creation of a notebook of examples from media and other sources a part of our QL courses.

These student notebooks also contain student analyses of the examples which range from the illogic of a political speech to misleading graphs and misuse of percentages. The positive feedback from students supports the extra work this involves for the instructor. This student comment from the graphical literacy course is typical: "I sincerely believe it will be one of the few classes I take here that will be useful in five years time."

— from Team Application

Breakout Session II-C

◆

THE CARLETON COLLEGE STORY

Time: 1:15 – 2:15 p.m. Date: Saturday, October 11, 2008 Location: LDC 345

LEARNING GOALS

Definition of Quantitative Reasoning: The aim of courses in Quantitative Reasoning is to further students' knowledge and understanding of mathematical and quantitative modes of thought. Some courses emphasize theoretical aspects of mathematics or statistical reasoning. Other courses in this area explore the application of quantitative methods to questions in disciplines across the curriculum.

Campus-wide Goal for Quantitative Reasoning: Students will understand QR so they can respond effectively to claims deriving from quantitative arguments.

Measurable Outcomes of Quantitative Reasoning: Students will understand how real-world problems and social issues can be analyzed using the power and rigor of quantitative methods while also learning to recognize and articulate the limitations of these methods.

Students will be able to do all of the following: evaluate interpret and draw inferences from mathematical models such as algorithms formulas graphs and tables. Students will be able to use quantitative methods (such as algebra geometry statistics and computation) to solve problems.

— from Team Application

Facilitators:

❖ Nathan D. Grawe
Associate Professor of Economics & Director of QuIRK
Carleton College

❖ Carol Rutz
Director of the Writing Program
Carleton College

Carleton's Quantitative Inquiry, Reasoning, and Knowledge (QuIRK) initiative began as a grassroots group of faculty who felt that greater attention to quantitative reasoning (QR) instruction would better equip our students for their future public, professional, and personal lives. Like many nascent curriculum reform efforts, while we were convinced we could do better we struggled to articulate clear student learning goals or even precisely identify "the problem." One member of the group suggested that we might solve these problems by reading actual student work to discern what was working, what was not, and what exactly we expect from students who have completed their general education requirements.

Fortunately, we have a huge collection of student work. As part of our writing requirement, each student entering the college in 2001 or later has been required to submit three to five papers at the end of the sophomore year. In a typical year, students submit papers written for 350 different courses taught by 200 different faculty members. By reading a random selection of these papers we were able to learn how students do and don't employ QR in a wide variety of contexts. Following our first reading, the committee developed explicit student learning goals with associated outcomes. In particular, we increasingly viewed QR through the lens of effective evaluation, construction, and communication of arguments. With support from the US Department of Education's Fund for the Improvement of Post-Secondary Education, QuIRK developed a rubric for assessing the extent and quality of QR in student papers. Given this integration of QR and writing, we have worked closely with Carleton's Writing Program.

In this break-out session we will share the story of QuIRK. After applying the most recent version of QuIRK's rubric to several excerpts of student writing, participants will discuss how a similar assessment strategy might be adapted to their campuses. We will also discuss how QuIRK's partnership with the Writing Program has helped QuIRK engage faculty from all disciplines in professional development and curricular reform. (In the last 12 months, half of all faculty have participated in QuIRK-sponsored activities. This total includes nearly 40% of faculty in the divisions of Arts, Literature, and Humanities.

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Breakout Session II

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NOTES

Time: 1:15 – 2:15 p.m. Date: Saturday, October 11, 2008

Notes:

Best Idea:

Learning Goals

The QR courses must address the General Education learning capabilities which include capabilities such as engaging in critical reading and analysis reasoning logically and quantitatively using technology to further education. More precisely students in the QR course should demonstrate the ability to reason quantitatively and use formal systems to solve problems of quantitative relationships involving numbers formal symbols, patterns, data, and graphs.

In this course students should: pose problems that involve quantitative relationships in real-world data by means of numerical symbolic and visual representations; solve problems deduce consequences formulate alternatives and make predictions; apply appropriate technologies; and communicate and critique quantitative arguments orally and in writing.

There is also topical knowledge that we expect students to learn. As described this includes basic numeracy understanding uses and abuses of statistics and understanding linear and exponential models. Less formally the goal is that students should be able to critically read graphs and quantitative information from the newspaper.

— from Team Application

Breakout Session III-A

GRANT SOURCES AND STRATEGIES

Time: 2:30 – 3:30 p.m. Date: Saturday, October 11, 2008 Location: LDC 302

Learning Goals

Key learning goals associated with the quantitative aspects of our revised BSc are to: introduce students to the interdisciplinary nature of modern science; instil an appreciation of the quantitative skills required for the practice of modern science regardless of discipline; help students gain an appreciation of the importance of modelling in science and to develop their abilities to formulate analyse apply and refine such models; improve students' mathematical statistical and computational skills in the context of scientific problems and issues; involve students in analysis of some "big picture" issues in science along with quantitative skills and knowledge required to analyse these issues; assist students in developing their ability to communicate responses to quantitative and science-based problems in a correct logical and scientifically appropriate style for both expert and non-expert audiences; help students understand and explain the nature of scientific data and the need for data management and statistical analysis; improve students' ability to identify and critically evaluate the role of data analysis and statistics in scientific research and publications.

— from Team Application

Facilitators:

❖ Rebecca Hartzler
Dean of Science & Mathematics & Professor of Physics
Seattle Central Community College

❖ Christopher Tassava
Associate Director of Corporate & Foundation Relations
Coordinator of Faculty Support
Carleton College

Building upon our experience with grants related to quantitative literacy and reasoning programs, this presentation— and the ensuing discussion— will cover the development of grant funded projects from the point of designing and writing the proposal to administering the project once funded. Topics include:

- **planning/applying phase:** identifying likely funders and working with program officers; establishing internal and external partnerships; choosing a focus of the project; creating a detailed project plan; and preparing viable applications (narrative, work plan, budget)— including pulling off the trick of sounding confident about a project that is essentially ephemeral.

- **grant phase:** maintaining internal and external partnerships, including between project leaders who can balance delusional optimism with orientation to details; obtaining the commitment of faculty and academic leadership to the project, especially as related to the inherently interdisciplinary nature of QR/QL projects; advancing project activities, including concrete curricular changes; meeting funder deadlines for reports and other contacts.

- **post-grant/continuation phase:** identifying sources of continuation funding (follow-on grants, endowment, general budget); writing proposals for additional grants (depicting achievements, plotting future progress, demonstrating need).

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Breakout Session III-B

◆

CREATING ENDURING RESOURCES

Time: 2:30 – 3:30 p.m. Date: Saturday, October 11, 2008 Location: LDC 330

Facilitator:

❖ Cathryn A. Manduca
Director of Science Education Resource Center
Carleton College

Enduring resources document the work of your project and its faculty participants on the web. These resources can support the work of your project by enhancing the ability of participants to implement workshop ideas, supporting dissemination on campus and beyond, and providing materials for use in project evaluation. This session will describe the evidence for the value of enduring resources, describe the strategies in place at Carleton and SERC to create enduring resources and the associated challenges, and provide time for you to brainstorm the ways in which you might incorporate creation of enduring resources into your action plan.

Session Resources:
Enduring Resources Developed by Quirk: http://serc.carleton.edu/quirk/index.html
Enduring Resources Created by Specific On the Cutting Edge Workshops:
Introductory Geoscience http://serc.carleton.edu/NAGTWorkshops/intro08/index.html
Affective Domain http://serc.carleton.edu/NAGTWorkshops/affective/workshop07/index.html
Sample Activity Submission Forms: http://serc.carleton.edu/sp/service/contribute.html

Please bring laptop to this session

Notes: Page 28

The Science Education Resource Center (SERC)

The Science Education Resource Center (SERC) works to improve education through projects that support educators. Although our work has a particular emphasis on undergraduate Science, Technology, Engineering, and Mathematics (STEM) education, we work with educators across a broad range of disciplines and at all eduWcational levels. An office of Carleton College, our work is funded primarily through National Science Foundation grants. The office has special expertise in effective pedagogies, geoscience education, community organization, workshop leadership, digital libraries, website development and program and website evaluation.

What do we do?

SERC's services to the education community lie in four primary areas.
- *Faculty Professional Development*
- *Bringing Science into Broader Use*
- *Community Visioning*
- *Research on Learning*

— http://serc.carleton.edu/index.html

Breakout Session III-C

GENERATING INTERDISCIPLINARY INSTITUTIONAL BUY-IN

Time: 2:30 – 3:30 p.m. Date: Saturday, October 11, 2008 Location: LDC 335

Learning Goals

The following excerpt from the faculty legislation of our new General Education curriculum expresses it well: "One of the goals of a liberal education in the arts and sciences is to help students develop an understanding of the nature of scientific knowledge especially the interplay between observations and theories and the process through which scientific knowledge progresses. Making one's own measurements and observations and then analyzing and communicating the results are crucial to this understanding.

Quantitative Literacy (QR) courses are those courses that teach students to understand and evaluate quantitative arguments and that help them develop the ability to apply quantitative skills to solve problems in multiple contexts. Quantitative literacy is not the same as knowledge of mathematics. Quantitative literacy is anchored in context and is data-based. Mathematics is less context-specific and is symbol-based. Quantitative literacy is a habit of mind usable in and across many fields.

— from Team Application

Facilitators:

❖ Caren L. Diefenderfer
Professor of Mathematics
Hollins University
❖ Neil Lutsky
Professor of Psychology
Carleton College

This session will address means of promoting quantitative reasoning across the curriculum. The workshop leaders will briefly review their own institutional initiatives to involve faculty and staff from across their campuses in their quantitative reasoning programs. We will highlight specific plans, programs, and insights that have contributed to institutional buy-in and also identify efforts that have proved less productive. Workshop participants will also be invited to describe techniques they have developed at their home institutions to encourage across the curriculum involvement in quantitative reasoning programs and teaching. In the second half of the workshop, we will assist participants in efforts to develop plans for programs or collaborations that might contribute to strengthening education in quantitative reasoning by faculty and staff from across their own campuses.

Resources: Pages 77, 79, 83
Notes: Page 28

Breakout Session III-D

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STUDENT SUPPORT SERVICES

Time: 2:30 – 3:30 p.m. Date: Saturday, October 11, 2008 Location: LDC 345

Facilitator:

❖ Linda W. Kirstein
Director of Quantitative Skills Program (retired)
Bowdoin College

The session will begin with a brief history of the development of the Quantitative (Q)-Skills Program at Bowdoin College. The various student support services offered within the Program will be described and the Q-Program activities needed to offer these services will be detailed.

Participants will then be asked to design the "ideal Q-support system" for their campus, taking into consideration their planned Quantitative Program, the services they would like to offer, and also their existing student support offerings. Participants will address such questions as: "Should the services be departmentalized or centralized?" "Should the services be accessible to all students or only to 'identified' students?" and "What staffing is needed to offer the desired services?"

At the end of the session, participants will share their "ideal systems" and offer suggestions to one another.

Related resources :
a. Handbook for Tutors: Table of Contents
b. Tutor Training Agenda - Day #1
c. Tutor Training Agenda - Day #2

Resources: Pages 87, 89
Notes: Page 28

Campus Culture

As on most campuses our faculty members believe there is plenty to do already without being asked to determine if all of our students have achieved a certain level of QR. If this is going to be a campus-wide endeavor many faculty members must be shown how to make an assignment which invites QR how to recognize when QR is being used and how to assess its effectiveness. Another challenge will be to make clear the distinction between the math proficiency requirement which we already have residing in the math program and a QR reasoning requirement which we plan to develop broadly across campus.

Our greatest asset is a faculty that is dedicated to teaching the students we enroll how to critically analyze information draw conclusions and communicate these conclusions effectively to others. The college has just completed a very inclusive strategic planning process that involved board members administrators faculty staff students and alumni. Quantitative reasoning was recognized and broadly supported by the board administration and faculty as an initiative to be undertaken. It was one of four aspects of the strategic plan that we focused on at our annual faculty retreat before the start of the 07-08 academic year.

— from Team Application

Breakout Session

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NOTES

Time: 2:30 – 3:30 p.m. Date: Saturday, October 11, 2008

In his famous 1959 lecture "The Two Cultures and the Scientific Revolution," C.P. Snow argued that there is a large and widening chasm between the sciences and humanities. Not all observers are as convinced as Snow was of the danger of the cultural separation, but few would claim that a reconciliation is near at hand. Still, a well-balanced curriculum connected to general education for all students can find ways to show that the various domains of learning are not remote islands of human thought and action, and indeed they can inform and complement each other.

— American Association for the Advancement of Science, *Designs for Science Literacy*. Oxford University Press, 2001.

Notes:

Best Idea:

Logistics

◆

SATURDAY AFTERNOON/EVENING & SUNDAY MORNING

Date: Saturday, October 11, 2008

Saturday Afternoon/Evening

3:30 – 4:30 p.m.	**Time for Relaxation and Personal Reflection**
4:40 – 5:50 p.m.	**Campus Team Meetings (including boxed dinners)** *Evans Dining Hall*
6:00 p.m.	**Buses Depart from Campus for Guthrie Theater** *A View from the Bridge by Arthur Miller*

Sunday Morning

7:45 a.m.	**Buses Depart Hotels for Campus**
8:30 – 9:45 a.m.	**Breakfast and Team Meetings** Finalize Action Plans

A View from the Bridge by Arthur Miller

Written by quintessential American dramatist Arthur Miller, A View from the Bridge is as timeless as the Greek tragedies on which it is modeled and as contemporary as today's headlines. Ethan McSweeny (Six Degrees of Separation, Romeo and Juliet, A Body of Water) directs this first-ever staging of Miller's acclaimed play at the Guthrie.

Longshoreman Eddie Carbone lives in the Red Hook section of Brooklyn with his wife Beatrice and her orphaned niece Catherine, whom they have brought up as their own daughter. Into the household come two of Beatrice's cousins from Italy who enter the country illegally to find work on the waterfront. Eddie's love for his niece turns to obsession when the younger of the Italian brothers, Rodolpho, and Catherine strike up a friendship that blooms into romance. Soon Eddie's conflicted feelings lead him to betray his family's trust and take action that ends in violence.

Plenary Session IV

TEAM REPORTS AND OPEN Q&A

Time: 9:45 – 11:15 a.m. Date: Sunday, October 12, 2008 Location: Evans Dining

Now...we inhabit a society inundated with numbers. The number skills needed to carry on doing life activities have increased, and while we have developed workarounds to simplify some of them, for example, computers and calculators in place of the "ready reckoner" tables of 1800, the need for numerical understanding is ever greater. We particularly run a danger because of a lack of numerical sophistication in the political realm.

Quantitative literacy is required to understand important political debates on issues such as Social Security funding, the differential effects of various tax-reduction plans, and health insurance options. Relatively few Americans have the quantitative savvy (and maybe also the time) to work through these policy debates and evaluate all their implications.

Facilitator:

- Jeanne L. Narum
  Director
  Project Kaleidoscope

Best Ideas:

Plenary Session IV

◆

TEAM REPORTS AND OPEN Q&A

Time: 9:45 – 11:15 a.m. Date: Sunday, October 12, 2008 Location: Evans Dining

Best Ideas:

Best Question:

So we take shortcuts instead, not all of them good. Thirty-second advertisements and the quest for the perfect sound bite for the evening newscast pressure politicians to reduce their take on a complex policy to a short, clear statement, which pictures the "typical "elder citizen and her projected savings on prescription drugs under candidate Y. Lacking the quantitative literacy to make sense of policies, voters substitute evaluations of the character and vision projected by candidates, trusting that the right person will delegate policy decisions to a team of experts sharing the general political ideology of the winner.

— Patricia Cline Cohen, "The Emergence of Numeracy." *Mathematics and Democracy: The Case for Quantitative Literacy*. The National Council on Education and the Disciplines, 2001.

Lunch and Plenary Session V

BUILDING A QR COMMUNITY: THE FUTURE OF THE NATIONAL NUMERACY NETWORK

Time: 11:30 a.m. – 12:00 p.m. Date: Sunday, October 12, 2008 Location: Evans Dining

In an era when knowledge is the key to the future, all students need the scope and depth of learning that will enable them to understand the scope and depth of learning that will enable them to understand and navigate the dramatic forces—physical, cultural, economic, technological—that directly affect the quality, character and perils of the world in which they live. ...In an economy where every industry—from the trades to advanced technology enterprises—is challenged to innovate or be displaced, all students need the kind of intellectual skills and capacities that enable them to get things done in the world, at a high level of effectiveness.

In a democracy that is diverse, globally engaged, and dependent on citizen responsibility, all students need an informed concern for the large good because nothing less will renew our fractured and diminished commons.

In a world of daunting complexity, all students need practice in integrating and applying their learning to challenging questions and real-world problems.

In a period of relentless change, all students need the kind of education that leads them to ask not just "how do we get this done?" but also "what is most worth doing?"

— AAC&U, *College Learning for the New Global Century*. 2007.

Facilitators:

- Corrine Taylor
  Director of Quantitative Reasoning Program
  Wellesley College
- H. Leonard Vacher
  Professor of Geology
  University of South Florida

The National Numeracy Network (NNN) offers its members a network of individuals, institutions and corporations united by the common goal of quantitative literacy for all citizens. Through national meetings, faculty workshops, research initiatives, and information sharing, the NNN aims to strengthen the capacity of our country in the quantitative areas of business, industry, education, and research across all disciplines.

Our Vision: The National Numeracy Network envisions a society in which all citizens possess the power and habit of mind to search out quantitative information, critique it, reflect upon it, and apply it in their public, personal and professional lives.

Our Mission: The National Numeracy Network promotes education that integrates quantitative skills across all disciplines and at all levels. To this end the NNN supports faculty development, curriculum design, assessment strategies, education research and systemic change. The NNN is the professional organization serving and promoting collaborations among those students, educators, academic centers, educational institutions, professional societies and corporate partners sharing our vision. The NNN also strives to keep issues of quantitative literacy at the forefront of national and international conversations about educational priorities.

In January 2008, the NNN launched Numeracy: Advancing Education in Quantitative Literacy, an open-access, peer-reviewed journal, in support of the organization's mission. The journal seeks evidence-based articles on teaching strategies and resources, education research, curriculum design, assessment strategies, and faculty development, as well as perspectives, reviews of educational resources, and commentaries/replies.

At Sunday's lunch and plenary session, NNN President Corri Taylor and Numeracy journal co-editor Len Vacher spell out their hopes for the future of the organization and the journal and describe your important role in making those hopes a reality!

Lunch and Plenary Session V

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BUILDING A QR COMMUNITY: THE FUTURE OF THE NATIONAL NUMERACY NETWORK

Time: 11:30 a.m. – 12:00 p.m. Date: Sunday, October 12, 2008 Location: Evans Dining

Notes:

Best Idea:

12:30 pm Bus Departs from Campus to Airport

PKAL Report on Reports II: Recommendations for Urgent Action

For the future, the nation will need a workforce equipped with more than literacy in reading, math, and science. We need a whole generation with the capacities for creative thinking and for thriving in a collaborative culture. We need a class of workers who see problems as opportunities and understand that solutions are built from a range of ideas, skills, and resources.

People are not born with inherent innovation skills, but they can learn them. They can acquire the social skills to work in diverse, multi disciplinary teams, and learn adaptability and leadership. They can learn to be comfortable with ambiguity, to recognize new patterns within disparate data, and to be inquisitive and analytical. They can learn to translate challenges in opportunities and understand how to complete solutions from a range of resources.

To quote Benjamin Franklin: "You tell me, I forget; you teach me, I remember; you involve me, I learn."

— Council on Competitiveness. National Innovation Initiative Summit and Report: *Thriving in a World of Challenge and Change.* 2005.

Table of contents

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Resources

Notes for Writing Action Plan

Action Plan

The agendas for action that emerge from a PKAL meeting are the most essential and meaningful outcome of your participation, as an individual and as a member of an institutional team. For almost twenty years, moving people from analysis to action has been a central PKAL thrust, whether the focus on attention is transforming program or spaces, developing faculty or budgets. Several key dimensions in regard to action have emerged from our work.

Vision Statement

These questions might help you articulate your vision for your program:

- How would you like your institution to look with regard to QR in five or ten years?
- How is this different from where you are?

Goal Statements

These questions might help you set goals that will allow you to realize your vision:

- What do you need to accomplish to bring that vision a reality? (Note: "So-and-so will present such-and-such proposal to the assessment committee" is not a goal. This is a strategy that works toward achieving the goal "Convince institution to adopt such-and-such assessment plan.")

Strategy Statements

These questions might help you identify strategies to achieve your goals:

- How are you going to engage your colleagues in this work?
- What are the challenges you expect to face? How will you address these challenges?

Action Statements

These questions might help you identify actions involved in carrying out your strategy:

- What's the first thing that has to happen for this strategy to succeed? What else needs to be done?
- When does each action need to be completed?
- Who is best positioned and will commit to do the task?

Of course, great plans untried will not create change. To help you move forward with your agenda, on Sunday each team will briefly present its plan to the group. In addition, we will post a summary of your plan (see below) on the workshop web page. Finally, we will be in touch with you in the coming years to find out how your action plan is progressing and to discuss how groups like the National Numeracy Network and other collaborators might help you continue moving forward. When you are done writing your plan, please email it to ngrawe@carleton.edu.

Public Summary

Because publicly sharing your strategies may be counterproductive, we won't post your goals, strategies, and action plans online. Rather, we would like you to summarize your plan in broad strokes for the web page.

Action Plan

Vision: [Vision Statement]

Goal: [What would we like to accomplish in the next 12 months?]

Strategy: [Strategy Statement]

Action: [Action Statement]

Action: [Action Statement]

Strategy: [Strategy Statement]

Action: [Action Statement]

Action: [Action Statement]

Note: Revise the number of strategies or actions as needed.

Goal: [What would we like to accomplish in the next 3 years?]

Strategy: [Strategy Statement]

Action: [Action Statement]

Action: [Action Statement]

Strategy: [Strategy Statement]

Action: [Action Statement]

Action: [Action Statement]

Note: Revise the number of strategies or actions as needed.

Note: Revise the number of goals as needed

Public Summary

[A 2-or-so paragraph summary]

10 Foundational Quantitative Reasoning Questions

Neil Lutsky, Professor of Psychology, Carleton College

I. What do the numbers show?

What do the numbers mean?
Where are the numbers?
- Is there numerical evidence to support a claim?
- What were the exact figures?
- How can seeking and analyzing numbers illuminate important phenomena?

How plausible is a possibility in light of back of the envelope calculations?

II. How representative is that?

What's the central tendency?
- "*For instance is no proof."*
- Mean, Mode, and Median.

Interrogating averages:
- Are there extreme scores?
- Are there meaningful subgroups?
- Who's in the denominator?
- What's the variability (standard deviation)?

What are the odds of that? What's the base rate?

III. Compared to what?

What's the implicit or explicit frame of reference?
What's the unit of measurement?
Per what?
What's the order of magnitude?

Interrogating a graph:
- What's the Y-axis? Is it zero-based?
- Does it K.I.S.S., or is it filled with ChartJunk?

IV. Is the outcome statistically significant?

Is the outcome unlikely to have come about by chance?
- "*Chance is lumpy."*
- Criterion of sufficient rarity due to chance: $p < .05$

What does statistical significance mean, and what doesn't it mean?

V. What's the effect size?

How can we take the measure of how substantial an outcome is?

How large is the mean difference? How large is the association?
Standardized mean difference (d): $d = (\mu_1 - \mu_2)/\sigma$

VI. Are the results those of a single study or of a literature?

What's the source of the numbers: PFA, peer-reviewed, or what?
Who is sponsoring the research?

How can we take the measure of what a literature shows?
The importance of *meta-analysis* in the contemporary world of QR.

VII. What's the research design (correlational or experimental)?

Design matters: Experimental vs. correlational design.
How well does the design support a causal claim?

Experimental Design:

Randomized Controlled Trials (RCT): Research trials in which participants are randomly assigned to the conditions of the study.
Double blind trials: RCTs in which neither the researcher nor the patient know the treatment condition.

Correlational Design: Measuring existing variation and evaluating co-occurrences, possibly controlling for other variables.

Interrogating associations (correlations):
Are there extreme pairs of scores (outliers)?
Are there meaningful subgroups?
Is the range of scores in a variable restricted?
Is the relationship non-linear?

VIII. How was the variable operationalized?

What meaning and degree of precision does the measurement procedure justify?

What elements and procedures result in the assignment of a score to a variable?
What exactly was asked?
What's the scale of measurement?
How might we know if the measurement procedure is a good one?
Reliability = Repeated applications of the procedure result in consistent scores.
Validity ≈ Evidence supports the use to which the measure is being put.

Is the measure being manipulated or "gamed"? The iatrogenic effects of measurement.

IX. Who's in the measurement sample?

What domain is being evaluated? Who's in? Who's not?
Is the sample from that domain representative, meaningful, and/or sufficient?
Is the sample random?
Are two or more samples that are being compared equivalent?

X. Controlling for what?

What other variables might be influencing the findings?
Were these assessed or otherwise controlled for in the research design?
What don't we know, and how can we acknowledge uncertainties?

Establishing the Quantitative Thinking Program at Macalester[1]

David M. Bressoud

In November 2005, the faculty of Macalester College voted to institute a graduation requirement in Quantitative Thinking (QT) that is truly interdisciplinary. It currently draws on courses from thirteen departments including Anthropology, Economics, Geography, Political Science, Theater, Mathematics, Environmental Science, and Geology. This article tells the story of how we brought this program into being and describes what this program looks like today.

Background and Origins of the Program

Macalester College is a highly selective liberal arts college of 1900 students located within the city of Saint Paul, Minnesota, the state's capital. Hubert Humphrey once taught here. Walter Mondale and Kofi Annan are alumni. The college has a reputation for being strong in the social sciences and very politically engaged. A commitment to internationalism has been a hallmark since the 1940s when Macalester became one of the first colleges to fly the United Nations flag.

In the summer of 2001, under a grant from the William and Flora Hewlett Foundation, the college organized faculty discussion groups to begin taking a critical look at the curriculum, in particular at the graduation requirements, with an eye to how it might be improved. Macalester's graduation requirements consisted of distribution requirements that included any two courses from the Science Division (including Mathematics and Computer Science), plus requirements in foreign language, international diversity, and domestic diversity. While many Macalester students did study mathematics or statistics, about a quarter of the student body avoided any courses with meaningful quantitative content.

That spring, a survey of our alumni had revealed that we were significantly below peer institutions in the proportion of our graduates using quantitative tools in their current activities. There was a growing awareness that our faculty culture was one that tolerated an aversion to quantitative thinking. This was becoming particularly acute in the social sciences where many departments found themselves split between older faculty who were uncomfortable with quantitative methods and younger faculty who embraced them.

I agreed to lead a faculty discussion group on quantitative reasoning. We had high interest. The group met every other week in the fall and continued meeting every three or four weeks in the spring. Twenty-one faculty and staff participated in some way during this year, and we had a core group of a dozen who showed up regularly. Three people played particularly important roles: David Lanegran, the chair of the Geography Department who, as both a Macalester alumnus and one of our longest serving faculty

[1] Under revision for *Numeracy*: *Advancing Education in Quantitative Literacy*.

members, is highly respected on campus; Vasant Sukhatme, chair of the Economics Department, who was instrumental in bringing that department firmly behind the initiative we would develop, and Danny Kaplan, an applied mathematician in the Department of Mathematics and Computer Science who brought energy, enthusiasm, and a total dedication to this project. The other departments represented in the planning process were Biology, Physics, Political Science, Psychology, and Sociology. In addition, the Dean of Academic Programs was a regular participant.

It did not take us long to agree on what we meant by quantitative reasoning. It included an understanding of sampling methodology and polling, experimental design and hypothesis formation, basic descriptive data, and correlation. A summary that we often invoked was that we wanted all of our students to be able to read quantitative information in *The New York Times* with critical understanding.

While it was easy to agree on the goal, it was much harder to find a way to get there. We struggled for several meetings to find a core of topics that could be incorporated into the introductory courses in a wide variety of departments, with the intention that all students would be required to take one of these introductory courses. But no one was willing to turn over the time needed to cover the quantitative topics that were not already part of their syllabus.

By early November, we had found a solution. Students in all of the participating introductory courses would be required to attend a common evening session that would cover quantitative topics that they might not see in their home course. In line with the interest of our students, this evening session would focus on quantitative reasoning for the purpose of analyzing questions of public policy. It would be a common experience in which students in many different classes, studying an issue of public importance from many different perspectives, could come together to hear experts in the field, share their insights, and gain an appreciation for a basic core of approaches to understanding quantitative information. We named our program Quantitative Methods for Public Policy (QM4PP).

We decided that each year would have a different public policy theme. We chose the school voucher debate for the first year because it is well-focused issue for which there is a rich collection of data, and also because it was a pet interest of the Dean of the Humphrey Institute of Public Affairs at the University of Minnesota, an organization that we wanted to involve.

We had strong support from President McPherson who promised sufficient funds to get the program started. I spent the spring of 2002 writing grant proposals and organizing a planning workshop that drew fourteen members of our own faculty as well as interested participants from Carleton, Grinnell, Lawrence, and St. Olaf. That summer, we were awarded funding by both FIPSE and the NSF. In the fall, we launched with five participating courses, two from Mathematics (discrete mathematics and statistics) and one each from Economics, Geography, and Political Science.

Trials and Tribulations

We ran into problems almost immediately. Broad participation was difficult to get because most faculty did not want to risk losing students from their introductory courses by requiring that they also sign up for the QM4PP class. We tried allowing faculty to make participation by their students voluntary. To no one's surprise, students did not enroll in QM4PP unless they were required to do so.

We had trouble figuring out exactly how the common evening class would connect to the individual participating classes. The original plan was to grant each instructor the freedom to decide how to establish these ties. Without guidance or mechanisms for enabling the connections, they often did not happen. The class time of Wednesday evening meant it was difficult for participating faculty to attend, aggravating the disconnect between what happened on Wednesday evenings and what was happening in the participating classes.

The topic of school vouchers was not ideal. We learned that most college students do not understand or at this point in their lives truly care about issues of public education.

But the biggest problem was at the core of what we were trying to accomplish: a common experience that these students could share. This necessitated about 120 students coming together for a single large class on a weekly basis. We had little experience with teaching large classes, and the students, most of whom had chosen Macalester because of its small classes, were resistant.

Formative assessment was always an important part of our process,[2] and before the first semester was completed we were making adjustments. One of these was to select immigration as the policy topic for the following year. This resonated with many faculty across the social sciences and humanities, could be tied to issues that energized our students, and was rich in possibilities for quantitative exploration. We held an initial planning workshop in January of 2003 involving sixteen Macalester faculty and a variety of community leaders working with immigrant issues in the Twin Cities. The January planning workshop was followed by a more extensive workshop in May of 2003.

Other adjustments were put in place. We began to explore ways of improving our teaching within a large class setting. This included the adoption of clickers and breaks for small group interaction during each class. The second and third years went much better, but the problem of getting faculty to require their students to participate in the program continued to plague us.

Fortunately, both the Economics and Mathematics departments were solidly behind this initiative. Most of the courses in Principles of Economics or Introductory Statistics

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[2] Jack Bookman was our consultant on assessment. Working with Dave Ehren, math specialist in the Macalester Excellence Center, he enabled us to keep abreast of what was and was not working in the class and helped us to consider alternatives.

participated. We had a sufficient number of students enrolled to run a meaningful program. We had envisioned our program as one that would reach math averse students. Economics and statistics were not the courses we had originally targeted, but we did have something to offer even these students. They would see how what they had studied in class played out in thinking about public policy debate. Still, it was clear we had a long way to go if we were to turn this into a program that would reach the students we felt most needed what we were offering. We hoped that once we had fixed the initial problems and QM4PP had become a graduation requirement, we would get broader participation from other departments.

Toward a Graduation Requirement

During the academic year 2003–04, the faculty committee on Educational Policy and Governance (EPAG) began to work on revisions to the graduation requirements. With the committee leadership shared by an economist and a political scientist, we were hopeful that they would recommend that the QM4PP program be adopted as a graduation requirement, thus giving many more departments an incentive to require their students to participate. But the work of the committee dragged into a second year when the leadership changed to individuals who were skeptical of any requirement for quantitative thinking.

Facing an unsympathetic EPAG committee and with our funding approaching its end, the future of a Quantitative Thinking (QT) requirement looked dark. Fortunately, over the years we had involved many of the Macalester faculty in a variety of aspects of the program: as guest speakers, as workshop participants, by bringing to campus some of the people they were interested in hearing. A total of 43 faculty, one in four of all our faculty members, representing sixteen different departments had participated in some way since the faculty discussion group began in Fall, 2001. QM4PP had built a broad base of general good will on campus. Our new president, Brian Rosenberg, made it clear that, while this was a faculty decision, he supported our efforts. By the end of the 2004–05 academic year, EPAG acknowledged the support we had on campus by agreeing to consider a proposal for a QT requirement. They gave us until September to specify exactly what it would entail.

As we strategized what we should put before the faculty, we realized that the common evening class would not fly. We had not been able to find an effective mechanism for integrating this common class into what was happening in the each of various participating classes. More importantly, we had been giving pre- and post-tests to assess how much the students were actually learning in our course. While we saw some improvement in some tasks and understandings, we were not seeing a dramatic improvement in either attitude or ability. One evening a week for a little more than an hour did not give us the opportunity for either the breadth or depth that would be needed in order to have a real impact on quantitative reasoning. Moreover, we were still encountering student resistance to the large class format.

Danny Kaplan led the efforts that summer to hammer out an agreement that would be built on individual courses and involve more departments. There were two directions we

could have gone. One was to identify courses with significant quantitative content in the context of social issues, courses such as Principles of Economics, Introductory Statistics as taught at Macalester, or a methods course in Psychology, Sociology, or Political Science, and to require all students either to take one of these or to take a general course that would build on the case studies and other materials developed in QM4PP. The other possible direction was to encourage many courses to include a quantitative module or component, and to require students to take several of these courses. The former option had the advantage that students would get an in-depth experience in using quantitative reasoning. The advantage of the latter was the sustained and varied exposure to quantitative reasoning.

The agreement reached that summer was to embrace both options.

The Final Solution

What emerged from the summer deliberations is somewhat complex, but the faculty accepted it—almost unanimously—and it works. At its heart is a refined definition of what we mean by quantitative thinking:

1. Describing the World Quantitatively: Much of quantitative thinking involves quantitative or statistical descriptions of social and natural phenomena. This includes descriptions of patterns and variations and rates of change, such as linear or exponential growth. Understanding descriptive statistics and the various modes of presentation of quantitative data is central. Students should be able to distinguish when quantitative approaches are appropriate and when they are not.

2. Evaluating Sources and Quality of Data: Students of quantitative thinking should also understand the sources of data, including the processes of collecting or producing data. This may involve understanding how to assess the reliability and validity of measurements and elements of probability and sampling, including sources of bias and error.

3. Association and Causation: The quantitative thinker knows the ways that associations between factors are established by observation, experiment or quasiexperiment. It is important to be able to establish the meaning of an association or correlation and learn the protocols for weighing the statistical significance and theoretical importance of findings, including inferring causation.

4. Trade-Offs: Most decisions, whether public or private, individual or societal, may be thought of as involving conflicting goals. Much of the debate on public issues involves disagreement about the value of the different goals. Where there are conflicting goals, quantitative thinking offers techniques for weighing the relative impact of policy options. While there rarely is a single correct outcome in the face of such conflicts, the quantitative thinkers can bring measure and balance to policy discussion.

5. Uncertainty and Risk: Few things in life are certain; decisions and debate often revolve around unknowns. The quantitative thinker possesses skills that can be used to assess, compare and balance risks, and understands the limits and strengths of these techniques. The quantitative thinker knows that, in the face of the unknown, if not the unknowable, we often rely on conditional statements and probabilities in making decisions and can evaluate conclusions drawn from conditional statements.

6. Estimation, Modeling, and Scale: The quantitative thinker understands that quantities vary over huge ranges; 'big' and 'small' are not absolute notions but depend on context or scale. Quantitative thinkers appreciate the value and limitations of abstracting out detail—constructing models—and that the sensitivity of model results to assumptions can and should be reported along with the model results.

Courses in Quantitative Thinking (QT) are designated at one of three levels:

Q3 The great majority of material covered in a Q3 course focuses on quantitative topics, and a Q3 course covers all or nearly all of the six learning goals.

Q2 At least half of the material covered in a Q2 course focuses on quantitative topics, and a Q2 course covers the majority of the six learning goals.

Q1 A Q1 course covers some of the six learning goals, and quantitative thinking elements represent some of the overall material covered in the course.

A student satisfies the QT requirement by taking either one Q3 course, two Q courses of which at least one of which is Q2, or any three Q1 courses. While the student who opts for three Q1 courses may not experience all six of the core goals of QT, it was decided that trying to keep track of which had not been covered would be a logistical nightmare. In view of the extended exposure to QT such students would receive, we could live with less than perfect coverage.

The designation is awarded for a particular class taught by a particular instructor during a particular semester, although when that instructor wants to teach that class again for QT credit, the vetting process is reduced to going online and checking a box that requests this designation and asserts that no substantial changes have been made to the course. For a first time request, the instructor fills out an online form that asks which of the six goals will be addressed, how they will be addressed, and how students will be assessed.

The fact that this is a QT requirement, not a mathematics requirement, is reflected in that many mathematics course as well as many courses in the natural sciences that are mathematically intensive receive no Q-designation, or only a Q1. The six goals were written to reflect the importance of being able to apply QT to the process of thinking about public issues. A course that does not do this, even were it to be billed as introductory statistics, would not qualify for Q3.

For Fall 2008, 48 sections of QT courses were offered, representing the departments of Anthropology, Biology, Chemistry, Economics, Environmental Science, Geography, Geology, Mathematics, Music, Physics, Political Science, Psychology, Sociology, and Theater and Dance. Thirty-two of these sections were designated Q1, four were Q2 courses, and twelve were sections of one of the following Q3 courses: Data Analysis and Statistics, Introduction to Statistical Modeling, Principles of Economics, Empirical Research Methods in Political Science, Research in Psychology, and the course that is dearest to my own heart, Quantitative Thinking for Policy Analysis. Because QT is now a graduation requirement and thus including enough quantitative material for a Q1 course makes your course more attractive to students, we have not had trouble enlisting Q1 courses. The Q2 designation is not used very much, but we never expected it to be.

QM4PP becomes QT4PA

QM4PP was always a misnomer since the focus was never on methods. The relaunch in Fall 2005 gave us the opportunity to rebrand the course as Quantitative Thinking for Policy Analysis (QT4PA). It is the direct descendant of the QM4PP course, scaled down in class size and beefed up in content. It is a course that is offered jointly by Economics and Mathematics, with each department responsible for teaching it once a year. Limited to 35 students, it draws on the many years of experience and the many presentations, examples, and case studies developed for QM4PP. Some of the pieces that go into this course include:

- An introduction to the display of data via *Gapminder* and the use of *Excel* spreadsheets to analyze and visualize the stories the data tell. Among the data bases we explore are the Bureau of Labor Statistics, the US Census Bureau, and the World Development Indicators,
- Basic work on the use of percentages, ratios, and rates, on compounding and exponential versus linear growth, and on probabilities (even Macalester students need this),
- An exploration of immigration issues with analysis of the quantitative information that each side marshals to support its position,
- Sampling issues, confidence intervals, and the interpretation of polling data,
- An analysis of correlation—what it means and how it can be measured—together with experience through examples of the problems encountered when we try to infer causality,
- Simpson's paradox, how it illustrates the dangers of aggregating data, and an analysis of the Berkeley study of sex bias in graduate admissions (Bickel *et al*, 1975),
- A basic introduction to cost/benefit analysis,
- A discussion of the need for trade-offs in any process of making policy decisions, with an analysis of the power and the limitations of quantitative tools, and
- Detection, especially the role of false positives, false negatives, and prevalence in assessing the usefulness of methods of detection. This is illustrated through the analysis of issues that include catching terrorists, diagnosing diseases, and

keeping unsafe food away from consumers.

The course culminates in an in-depth study in which students gather and assess quantitative and other information relevant to a policy question, draw conclusions and make recommendations, and then present these both orally to the rest of the class and in a written paper.

There is no textbook, but we do use books by Best (2001, 2004) and Gigerenzer (2002) as starting points for class discussion.

The course is extremely popular. Part of the reason for this is that it satisfies both the QT requirement and half of the distribution requirement for courses in the Science Division. But I also think it is popular because the course is practical, interesting, and engaging. Student feedback indicates that they enjoy the course and believe that it is providing them with a way of looking at the world that enriches their understanding of its complexities.

Ongoing Assessment

QT became a graduation requirement beginning with the class of 2011. When these students matriculated in Fall, 2007, they also became the first subject to our new college-wide assessment program. This consists of instruments designed to measure student ability in writing, quantitative reasoning, international understanding, and multicultural understanding. The instruments are administered to incoming first-year students and again at the end of the sophomore and senior years.

As a benchmark, we are using the Collegiate Learning Assessment (CLA). Against this is an instrument that Danny Kaplan has been developing specifically for Macalester. The Macalester questions on quantitative reasoning were derived from the summative tests used for the QM4PP program. The following provide an example of the kinds of questions that are asked.

Here is the tuition (per semester) at some elite colleges in 1947 and 200&;

School	1947	2007
Princeton	$520	$16,500
Columbia	$544	$16,832
Harvard	$494	$15,728
Williams	$524	$16,739
Yale	$650	$17,265

During the 60-year period between 1947 and 2007, how many times has the typical tuition doubled?

A. 2 times
B. 5 times
C. 10 times
D. 32 times

A simple way to approximate the annual growth rate (in percent per year) is that the doubling time (in years) divided into 72 gives the growth rate. For example, a doubling time of 24 years corresponds to a growth rate of 72/24 = 3 percent. This is called the "Rule of 72" and is a useful rule of thumb.

According to the Rule of 72, what has been the typical annual growth rate in tuition over the past 60 years?

A. 3 percent per year
B. 6 percent per year
C. 12 percent per year
D. 20 percent per year

What is the typical inflation rate in the US economy?

A. 0 percent per year
B. 1 percent per year
C. 3 percent per year
D. 6 percent per year
E. 10 percent per year

A certain town is served by two hospitals. In the larger hospital about 45 babies are born each week, and in the smaller hospital about 15 babies are born each week. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from week to week. Sometimes it may be higher than 50 percent, sometimes lower. For a period of one year, each hospital recorded the weeks on which more than 60 percent of the babies born were boys. Which hospital do you think recorded more such weeks?

A. The larger hospital
B. The smaller hospital
C. About the same (there is no reason to expect that one hospital will have more such weeks than the other)

There are many difficulties with our assessment that are still to be worked out such as how to get sophomores and seniors to take these instruments seriously and how to measure international and multicultural understanding. The CLA is very quantitative, providing a reasonable assessment of student ability to analyze quantitative information and use it effectively to support an argument. At the very least, we hope to get a good picture of how our students' ability to reason with quantitative information develops over their four years.

Lessons Learned

The lessons that we learned are very similar to those cited by Steele and Kiliç-Bahi (2008) in their description of the development of a Quantitative Literacy (QL) program at Colby-Sawyer. These include the need for broad participation, a focus within the QL program on interdisciplinarity, a faculty culture of collaboration and innovation, a supportive administration, adequate funding, and an institutional commitment to student learning. I would add one more: a willingness to be flexible.

Institutional change is a long, slow, and uncertain process. It requires participation that is both broad and deep. We never would have succeeded if we had not touched such a large fraction of our faculty as we developed this program, and we never would have succeeded if we had not had those few people who were totally committed to this vision. We needed those who showed up regularly, those who participated occasionally, and those who limited their involvement to encouragement from the sidelines.

If this had only been a project of the Math Department, or even Math and Economics jointly, we would not have succeeded. In order to get such broad participation, the program needed to be interdisciplinary. While most of the leadership came from Mathematics and Economics, there were faculty from Geography, Sociology, and Political Science who were heavily involved and were able to play important roles at critical junctures.

Macalester has a very active Center for Scholarship and Teaching (CST). The QM4PP program came under its aegis, thus providing a home for clerical support and a vehicle for promoting participation. The general atmosphere of concern for excellent teaching and willingness to experiment that the CST has fostered was important in setting a context in which QM4PP could flourish.

From the initial planning session attended by the Dean for Academic Programs to the final push for faculty adoption that was unambiguously supported by our president, the administration was supportive, most significantly by guaranteeing the resources that would be needed as we made each move to the next stage.

Money is important. The task was much larger than anyone envisioned, and it would not have happened without release time for Danny Kaplan and myself. Being able to hire Jack Bookman as our consultant on assessment and Steve Holland, a PhD Economist on a half-time position to teach in and to develop materials for the QM4PP program, was very important. We ran at least one and usually two workshops per year. These provided means to educate and involve many of our faculty and made it possible to reach out to the wider community, a process that provided both support and insight. Money cannot buy the commitment that provides impetus, but it can grease a process that inherently encounters a great deal of friction.

The focus on student learning meant that few faculty argued with our goal of improving student reasoning with quantitative information. Even those who would consider themselves math averse recognized the importance and usefulness of this skill. Our challenge was limited to coming up with a program that could reach our goal efficiently.

Tenacity needs to be tempered with flexibility. Looking back, we can see that we preserved all that was really good in our initial vision, even though what did emerge is quite different from where we thought we would be. The continual process of formative assessment was punctuated at one- to two-year intervals by two-day workshops when we would bring in a few outside observers, put everything on the table, then sit back and

brainstorm what could or should be done differently. On the other hand, there came the time in 2004–05 when we had to articulate a coherent plan and sell it to the faculty. One of the hardest parts of the process was determining what was essential and what was peripheral.

For those who would seek to create a program in Quantitative Reasoning at their own college or university, my advice would be to first articulate your goals in a language that makes sense for your institution, keep in mind the lessons learned at Colby-Sawyer and Macalester, and remember that an effort like this is only do-able and worthwhile if it is something you care deeply about and enjoy.

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This material is based upon work supported by the US Department of Education Fund for the Improvement of Post-Secondary Education under Grant No. P116B020918 and the National Science Foundation under Grant No. 0229967. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the US Department of Education or the National Science Foundation.

Case Studies for Quantitative Reasoning
A Casebook of Media Articles

by

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July 2008

Supported by the National Science Foundation
Grant # DUE-0715039

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Introduction – Case Studies for Quantitative Reasoning

This casebook is based on three years of work in developing and delivering an ever-fresh, real-world-based course that starts students down a path toward quantitative literacy (QL). Development of the course was prompted by two circumstances. First, beginning in 2000, the lead author, Bernard L. Madison, worked in the QL initiatives that Robert Orrill of the National Council on Education and the Disciplines led, and during that work began collecting news media articles that included quantitative information, analyses and arguments. The articles in the cases in this book are only a small fraction of the ones collected. Second, students in the social sciences, arts, and humanities at the University of Arkansas were required to complete a mathematics course which had college algebra as a prerequisite, and there was not a suitable course available. This course now meets that requirement.

This casebook is a work in progress. This is a preliminary edition, and we expect to make changes in both format and content. Suggestions are welcome and are best conveyed by email to bmadison@uark.edu or sdingman@uark.edu.

In developing the course and teaching it over the past three years, numerous pedagogical challenges have been encountered, including the habits students have acquired from traditional courses in mathematics and statistics of expecting artificially crafted template problems with definite and precise algorithmic solutions. These cases, mostly based on articles from current newspapers and magazines, are a far cry from template problems but much closer to students' interests and needs in everyday life. These differences offer significant challenges for the instructor both in class and in assessment.

This book contains case studies of twenty-three public media articles, mostly from newspapers. Also included are introductory notes and exercises on the basic concepts of comparing quantities; percent and percent change; indices; interest on money; weighted averages; graphical interpretation; counting; and probability, odds and risk. Each of the articles contains quantitative information, analyses, or argument. These case studies are meant to be both items of study and examples of case studies that students and teachers can create using public media articles from the present day, keeping the material fresh and more obviously relevant. In fact, student engagement in the course we teach is increased because students are encouraged to bring in articles that illustrate QL to discuss in class. By creating case studies and discussing those in this book, students will develop reasoning skills and disposition toward continuing practicing those skills beyond

> Quantitative literacy (QL) is a habit of mind, and, consequently, achieving QL requires both extensive interaction between students and teachers and practice beyond school. At the collegiate level, we are concerned with a high level of QL, befitting persons with baccalaureate degrees, analogous to what Lawrence Cremin (1988) termed liberating literacy, as opposed to inert literacy. Therefore, the QL we seek includes command of both the enabling skills needed to search out quantitative information and power of mind necessary to critique it, reflect upon it, and apply it in making decisions.
>
> Cremin, L. A. (1988). *American education: The Metropolitan experience 1876-1980*. New York. NY: Harper & Row.

a course and beyond school. They will develop a habit of mind to reason quantitatively in their everyday life as a citizen, consumer, and worker.

This approach to teaching toward quantitative literacy (QL) is based on the assumption that there are canonical QL situations that students need to address and resolve. These situations very often involve the following steps:

- Encountering a challenging contextual circumstance, e.g. reading a newspaper article that contains the use of quantitative information or arguments.
- Interpreting the circumstance, making estimates as necessary to decide what investigation or study is merited.
- Gleaning out critical information and supplying reasonable data for data not given.
- Modeling the information in some way and performing mathematical or statistical analyses and operations.
- Reflecting the results back into the original circumstance.

These steps often require careful reading of both continuous prose and discontinuous prose (such as graphical representations), using mathematics or statistics, and then interpreting and critiquing the original prose in light of the mathematical results. Critical reasoning is required throughout. In general, students are not expecting this complicated process because their previous mathematics experiences have been narrower and better defined. Consequently, a teacher may struggle with breaking the process into bits and pieces and teaching these separately. Frequently, the fourth phase gets the most attention because it is the process of traditional mathematics and statistics courses.

Many of the problems are ill-posed and require reasonable assumptions to resolve, and many of the problems have multiple reasonable responses. Consequently, conclusions require explanations of reasoning that led to the conclusions.

The Course Philosophy

Our experience with the course that has been developed over the past three years – which we call QL-friendly – has led us to a few conclusions about desirable characteristics of such courses, and, on the flip side, some conclusions about why traditional courses are not QL-friendly. Some of these characteristics are alluded to above, but we reiterate them here.

- Mathematics is encountered in many contexts such as political, economic, entertainment, health, historical, and scientific. Teachers will require broader knowledge of many of the contextual areas.

Mathematical Proficiency from *Adding It Up*

- conceptual understanding – comprehension of mathematical concepts, operations and relations
- procedural fluency – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- strategic competence – ability to formulate, represent, and solve mathematical problems
- adaptive reasoning – capacity for logical thought, reflection, explanation, and justification
- productive disposition – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.

- Pedagogy is changed from presenting abstract (finished) mathematics and then applying the mathematics to developing or calling up the mathematics after looking at contextual problems first.
- Material is encountered as it is in the real world, unpredictably. Unless students have practice at dealing with quantitative material in this way they are unlikely to develop habits that allow them to understand and use the material. Productive disposition as described by Kilpatrick, Swafford and Findell (2001)[1] is critical for the students.
- Much of the material should be fresh -- recent and relevant.
- Considerably less mathematics content is covered thoroughly.
- The mathematics used and learned is often elementary, but the contexts and reasoning are sophisticated.
- Technology – at least graphing calculators – is used to explore, compute, and visualize.
- QL topics must be encountered across the curriculum in a coordinated fashion, requiring those encountered in a QL-friendly course to make cross-curricular connections.
- An interactive classroom is important. Students must engage the material and practice retrieval in multiple contexts.

Our Classrooms

The course we have taught meets on Tuesdays and Thursdays and carries three semester hours of credit. Most of the thirty scheduled 80-minute periods proceed as follows:

1) News of the Day. Students will bring items to class from recent publications and present the material to the class. Credit toward course grades will be given for bringing news items that contain mathematics and explaining the mathematical content to the class or raising valid questions about the mathematics. Each student is encouraged, but not required, to bring and present at least one article, and each student is encouraged to bring and discuss several articles.

2) Brief introduction to the mathematical topics to be studied.

3) Article(s) of the day. Discussion of news article(s) that contains substantial mathematical material and extending the mathematics. Sometimes the articles of the day will be discussed for more than one class period. Group exercises will contain questions about the articles.

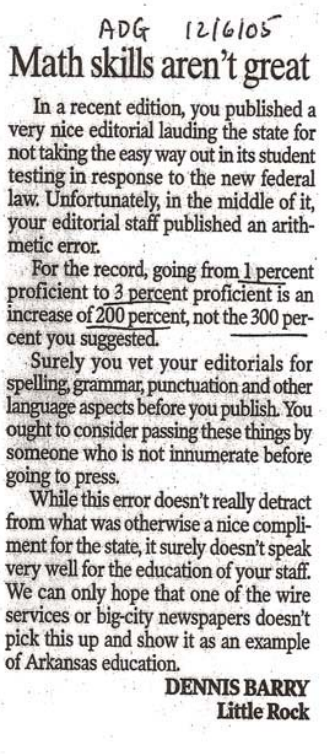
4) Homework assignment. This will sometimes consist of newly collected articles with mathematical arguments to be analyzed for the next class meeting. Work related to some material from the article of the day will often be part of the homework.

[1] Kilpatrick, J., Swafford, J., & Findell, B., Eds. (2001). *Adding it up*. Washington, DC: National Academies Press.

5) Examination material will include questions similar to material in group exercises and homework, questions about mathematical and statistical concepts discussed in class, and new material contained in newspaper and magazine articles. All quizzes and examinations include articles new to the students and questions about those articles.

An Example of Issues Related to Assessment

We use the following, relatively simple letter to the editor to make a point about assessment. An assessment item asked students to respond to the following questions and requests.



ADG 12/6/05

Math skills aren't great

In a recent edition, you published a very nice editorial lauding the state for not taking the easy way out in its student testing in response to the new federal law. Unfortunately, in the middle of it, your editorial staff published an arithmetic error.

For the record, going from 1 percent proficient to 3 percent proficient is an increase of 200 percent, not the 300 percent you suggested.

Surely you vet your editorials for spelling, grammar, punctuation and other language aspects before you publish. You ought to consider passing these things by someone who is not innumerate before going to press.

While this error doesn't really detract from what was otherwise a nice compliment for the state, it surely doesn't speak very well for the education of your staff. We can only hope that one of the wire services or big-city newspapers doesn't pick this up and show it as an example of Arkansas education.

DENNIS BARRY
Little Rock

Refer to the December 6 letter to the editor, *Math skills aren't great.*
Used with permission, ©2005, *Arkansas Democrat-Gazette.*

a) Find the increase in percent proficient.
b) Find the percent increase in the percent proficient.
c) Is the letter writer correct that the original article was wrong? Why
d) Is the letter writer correct or incorrect when he states, "going from 1 percent proficient to 3 percent proficient is an increase of 200 percent?" Why?

Response #1

a) Find the increase in percent proficient.

1% X=3% x=300%

b) Find the percent increase in the percent proficient.

.01 x 3.00 or .01 x 300% = .03

c) Is the letter writer correct that the original article was wrong? Why?

No, he did not correctly calculate the percent change.

d) Is the letter writer correct or incorrect when he states, "going from 1 percent proficient to 3 percent proficient is an increase of 200 percent?" Why?

No, it is an increase of 300%, not 200%

Response #2

a) Find the increase in percent proficient.

1% ⟶ 3%
The percent proficient increased by two percentage points.

b) Find the percent increase in the percent proficient.

$\frac{3\%-1\%}{1\%} \quad \frac{2}{1}=2 \quad 2\times100=200$ a 200% increase

c) Is the letter writer correct that the original article was wrong? Why?

The letter writer was correct, but he needs to calm down a bit. It was a small, common mistake, but a mistake nonetheless.

d) Is the letter writer correct or incorrect when he states, "going from 1 percent proficient to 3 percent proficient is an increase of 200 percent?" Why?

He is correct. The editorial assumed that if the # tripled, it would mean it increased by 300%. What the editorial forgot to do was add on to the original # to the problem.
1% ↗ 2%
X2 +1% 3% It is the same reason why a number that doubles increases only 100%

Response #3

a) *Find the increase in percent proficient.*

Increase in percent: 3% - 1% = 2% increase

b) Find the percent increase in the percent proficient.

Percent increase: $\left(\frac{3-1}{1}\right)\times100=200\%$

c) Is the letter writer correct that the original article was wrong? Why?

Yes, because if the percent increase was to be 300% like the original article stated, the ending proficiency would need to be 4% instead of 3%.
Ex: $\left(\frac{4-1}{1}\right)\times100=300\%$

d) Is the letter writer correct or incorrect when he states, "going from 1 percent proficient to 3 percent proficient is an increase of 200 percent?" Why?

The letter writer is incorrect in making that statement due to a misuse of wording. The letter writer made an error in saying "increase of 200%," when he should have said "it's a percent increase of 200%."

These responses provide examples of some recurring assessment issues using the case study approach.

1) Most would say that the letter writer is correct in answering part d). However, response #3 (which is the strongest of the three) disagrees and says why. If the "why" were not there, then this would have been a weak (and probably judged incorrect) response.
2) Response #1 provides a common weak response by stating something ("No, he did not correctly calculate the percent change.") that is correct (if one correctly attributes the meaning of "he") but with no rationale for doing so.
3) Responses #2 and #3 provide examples of showing calculations that support assertions in responding to part b).

These three student answers provide examples of strong and weak responses that students should be reminded about frequently:

A Making assertions without supporting reasoning or evidence. (Weak)
B. Giving numerical results without indicating the calculations that produce the results. (Weak)
C. Stating numerical evidence in complete and correct sentences. (Strong)
D. Recognizing that precision of language is important. (Strong)

Content of Casebook

As mentioned above, there are three different types of materials in this book:

1) Introductory notes on basic concepts
2) Exercises on the basic concepts involved in case studies
3) Case studies of the articles

Case studies of articles consist of the article under study and a list of questions or tasks about the article. The questions and tasks take different forms, including the following:

a) Identifying and reporting quantitative information and arguments from the articles.
b) Developing additional quantitative information from information in the articles.
c) Critiquing the arguments, analyses, and conclusions of the articles.
d) Extending the arguments beyond those in the articles.
e) Research and reporting on concepts related to the articles.

The questions and tasks in the case studies of the articles can be used in various ways: discussed in class; some assigned for student responses; all assigned for student responses; or discussed in groups of students in class to produce a group response.

The content is arranged in six sections, sorted by basic concepts that occur in the articles, but various concepts recur throughout the case studies. Occasionally, concepts that are unfamiliar to students are encountered without full explanation. For example, it is assumed that students can produce graphs of linear and exponential functions. Skipping sections will likely not mean that material that is needed later is being omitted.

Prerequisites

Proportional, graphical, statistical, and algebraic reasoning are required to analyze these cases in this book. Basic knowledge of algebra, descriptive statistics, and proportionality is necessary, but there is little dependence on algorithms and complex mathematical concepts. No knowledge of trigonometry, analytic geometry, or calculus is assumed, but the ideas of all three (proportionality, geometry, rate of change, approximation, etc.) are very helpful in fully developing the study of various cases. In terms of course prerequisites, students need to have a working knowledge of middle school mathematics and high school algebra (or college algebra). The sophistication of the case studies derives mostly from the contexts that span economics, sociology, politics, government policies, entertainment, health, and measurement.

Comments Are Invited

Case study pedagogy is not common in college mathematics. We are still learning about how to best use cases for student learning. As noted earlier, we welcome suggestions on content and pedagogy as well as observations regarding conceptual hurdles for students and language or vocabulary issues. Suggestions can be sent to bmadison@uark.edu or sdingman@uark.edu.

Acknowledgement

We gratefully acknowledge support of the National Science Foundation for the further development and expansion of this course (DUE-0715039).

Examining the Federal Poverty Line

Setting Context:

*source: U.S. Census Bureau, Census 2005

Milwaukee has the 7th highest rate of poverty out of all Metropolitan Cities in the United States; 26.0% of Milwaukee residents live below the federal poverty line. In this activity, we will review our MT 050 Unit I Criteria as we critically examine the federal poverty line. We will examine historic and current poverty line calculations, including the assumptions within those calculations. Ask yourself, "How realistic are the budgetary guidelines used to calculate the federal poverty line? How meaningful is the federal poverty line?"

1. History of the poverty line
   a) Carefully read the following passage:
      *source: Shannon, P. (1998). *Reading Poverty*. Portsmouth, NH: Heinemann.

      "In 1963, the President's Council of Economic Advisors (CEA) set an official poverty line for the first time. Using a U.S. Department of Agriculture (USDA) report written by Mollie Orshansky, which determined that a typical family of four could prepare three minimally adequate meals a day on exactly $2.736, the CEA established $3,000 in income as the poverty line ($2.736 x 365 days = $998.64 x 3 [because the average family in 1963 spent one-third of their income on food] = $2,995.92….Since 1963, no adjustments have been made in the official poverty equation to accommodate the many changes in Americans' standard of living" (Shannon, 1998, p. 42).

   b) What do you believe is the perspective of the author on the way the poverty line is calculated? What leads you to believe this?

2. The poverty line today
   *source: US Census Bureau. *Income, Poverty and health Insurance Coverage in the United States: 2007*. 8/08

   a) The 2005 poverty line for a family with three members is sixteen thousand, seven hundred five dollars. Write this number in digits.

   b) Calculate the average weekly income for a family with three members living at the poverty line.

   c) The federal minimum wage is $5.85 per hour. How many hours would a minimum wage earner need to work, per week, to earn the average weekly income for a family with three members living at the poverty line?

   d) If this family budgets one-third of their income for food (the fraction that poverty line calculations are based upon), how much money could they spend on groceries per week?

3. Calculating the cost of food

a) Calculate the missing values in the tables below:

Cost of Groceries

*source: Pick 'n Save Food Store, 4698 S Whitnall Ave, St. Francis WI

	Cost (lowest priced brand)	Servings per package	Cost per serving (rounded to the nearest cent)
Skim milk	$3.09	16 cups	
Chicken breasts (bulk bag)	$6.99		$0.58
93% lean ground beef		5	$0.73
Tuna (canned)	$0.44	2.5	
Black beans (canned)		3.5	$0.20
Vegetables (canned)	$0.50	3.5	
Vegetables (frozen)	$1.25		$0.25
Potatoes (bag)		15	$0.15
McIntosh apples (bag)		14	$0.19
Peaches (canned)	$0.75	3.5	
White rice	$1.09	20	
Dry spaghetti		8	$0.09
Spaghetti sauce (canned)	$1.08		$0.18
Peanut butter		16	$0.11
Grape jelly	$1.39	25	
Oat cereal with berries	$1.90		$0.10
Wheat bread	$0.88		$0.04
Coffee	$2.55		$0.03
Flavored gelatin mix (box)		4	$0.14
Olive oil	$2.99	17	

United States Department of Agriculture Estimated Nutritional Needs

*source: www.mypyramid.gov

	33 year old female, Moderately active	6 year old female, Highly active	4 year old male, Highly active	Totals
Grains	6 ounces	5 ounces	5 ounces	
Vegetables	2.5 cups	2 cups	2 cups	
Fruits	2 cups	1.5 cups	1.5 cups	
Milk	3 cups	3 cups	3 cups	
Meat and Beans	5.5 ounces	5 ounces	4 ounces	
Oils	6 teaspoons	5 teaspoons	4 teaspoons	

3. Calculating the cost of food, cont.

b) Recall (from 2d) the amount of money that a family with three members living at the poverty line would budget for weekly groceries, if they were able to budget one-third of their income for food: _____

c) According to the USDA's estimated nutritional needs, how many servings (cups) of milk are needed by a family with three members each week (7 days)?

d) Calculate the weekly cost of milk for a family with three members (use your answer from 3c).

e) What fraction of the weekly grocery budget of a family with three members living at the poverty line is (or should be) spent on milk, according to the USDA's estimated nutritional needs?

f) Convert the fraction in 3e into a percent. What does this percent mean? Explain, using a complete sentence.

g) Approximate the fraction in 3e.

h) Which costs more, a breakfast consisting of 1 slice of bread with peanut butter and jelly, or a breakfast consisting of one serving of oat cereal with ½ cup of milk? Show your work.

i) How many meals of beans and rice (one serving each of black beans and white rice) could you prepare for the cost of one meal of spaghetti and meatballs (one serving each of dry spaghetti, spaghetti sauce, and ground beef)?

4. Calculating the cost of housing

a) Recall (from 2a) that the federal poverty line for a family with three members is $16,705 per year. Calculate the monthly income for a family with three members living at the poverty line.

b) Calculate the monthly income (from 4a) *left over* after one-third of the total monthly income is budgeted for food (from 2d).

c) Complete the following table:

Rent in Metro Milwaukee
*source: *Milwaukee Journal Sentinel*, September 15, 2008

Description	Location	Rent	Percent of total monthly income
2 bedroom apartment, does not include heat	27th and Loomis Ave.	$600	
3 bedroom apartment, heat is included	95th and Silver Spring	$800	
2 bedroom apartment, heat is included, pool	68th and Layton Ave.	$690	
3 bedroom upper, includes garage, does not include heat	N 53rd and Hadley	$785	

d) Which of these rental properties do you believe might be the "best" selection? Explain your reasoning.

5. Calculating the cost of transportation
*source: www.ridemcts.com, 9/15/08

1. A weekly bus pass for the Milwaukee County Transit System costs $16.00 per adult and $10.00 per week for children ages 6 -11 (children under 6 years of age ride free). Calculate the monthly transportation expense for a family of three (1 adult, 1 six year-old child, and 1 four year-old child).

2. Approximately what fraction of the total monthly income for a family of three living at the poverty line is spent on transportation?

6. Putting it all together

a) So far, we have examined the cost of food, housing, and transportation for a family with three members (one adult and two children). What other *essential* monthly expenses can you think of? List three other items, and approximate what each item might cost per month. (You may wish to discuss this question with classmates.)

Item 1: Cost per month:
Item 2: Cost per month:
Item 3: Cost per month:

b) Refer back to the calculations you have completed throughout this activity, and fill in the following data table:

Monthly Budget for a Family of Three Living at the Poverty Line

Total Monthly Income:	
Cost of food:	
Cost of housing:	
Cost of transportation:	
Item1:	
Item 2:	
Item 3:	
Monthly Income Remaining:	

7. Reflection: Review your work and think about the questions below.
Recall from problem 1 (History of the poverty line) that poverty line calculations are based upon the presumption that families spend one-third of their income on food. How realistic is this presumption? How does it relate to the family of 3 budget you determined above. How meaningful is the federal poverty line? If a family's total income is slightly higher than the federal poverty line ($16,705 for a family of three), can we assume that family is financially self-sufficient? Should there be changes in the way poverty line income is determined? Why or why not?

Response: Write a letter to your Senator.
Use these questions and/or other observation and calculations to write a letter to your Senator (Sen. Feingold or Sen. Kohl) explaining what you've learned about the poverty line. Make sure to include specific numerical evidence for your position. *Please keep your level one writing criteria in mind while writing this letter.*

The story behind the numbers

1. What was the context of your activity?

2. What were the key tasks you needed to perform, and what were the math skills you used?

3. How did this experience compare to math as you remember it in your education?

4. What did you think about or find yourself doing that you hadn't done before?

5. As a teacher in your discipline, what are the implications for your students of this method of learning math?

Multiplying math perspectives: the math/non-math equation

1. How I currently use math in my courses:

2. How I can
   a) make math more explicit in my courses:

   b) promote a positive attitude towards math in and out of the classroom:

   c) further develop quantitative literacy in my courses:

3. "Math is a way of understanding and changing my world."
   What is the relationship of mathematics to my discipline/ where do I see math in my discipline?

Quantitative Literacy Survey

In an effort to support quantitative learning across the curriculum, the Communication Department requests that you fill out this survey. We appreciate your time.

Enter the following information:
Major: _____ Support: _____
WDC/WEC Age: _____

1. In your major or support area, please give an example of how you have solved a problem using quantitative relationships, information or strategies.

2. Describe a situation in your major or support area where you used quantitative information or language to convey your ideas.

3. What learning experiences would you recommend to support students' development of quantitative abilities?

4. How would you rank your confidence level of using quantitative information and language in your discipline? (Please circle one.)

1	2	3	4	5
Low Confidence	Some Confidence	Moderate Confidence	High Confidence	Very high Confidence

5. Given the opportunity, do you find yourself using quantitative information and language in your discipline ..

1	2	3	4	5
only when specifically directed to do so?		on your own initiative?		comfortably on your own initiative?

Alverno College Communication Ability Department
Quantitative Literacy Criteria

Level 1: Uses arithmetic and algebraic methods to solve problems accurately.

- Shows awareness of specific strengths and weaknesses in her own quantitative performance.
- Performs and applies four basic operations using the Rational Number System.
- Solves ratio and percent problems related to everyday living.
- Solves and applies algebraic equations and inequalities.
- Uses quantitative skills in order to help recognize, create and solve problems related to everyday living.

Level 2: Interprets math models such as formulas, graphs and tables and draws reasonable inferences from them.

- Interprets, selects and constructs graphs using graphing software.
- Analyzes and visualizes geometric concepts.
- Applies measurement concepts.
- Expresses relationships as equations and/or graphs using spreadsheet software.
- Interprets and predicts data using basic probability concepts.
- Interprets, predicts and presents data using basic statistical concepts.

Level 3: Thinks critically about her own and others' use of quantitative information and language.

- Identifies quantitative relationships within a context.
- Shows awareness of the assumptions behind quantitative information.
- Shows awareness of the use/misuse of quantitative information.
- Recognizes the relationship between quantitative information and how it is presented to an intended audience.
- Uses basic quantitative abilities to accurately interpret quantitative information and evaluate arguments.

Level 4: Integrates quantitative abilities to effectively communicate information and respond to problems within a discipline related context.

- Shows evidence of a reflective, deliberate choice to use quantitative information in a discipline related context.
- Considers use of and, as appropriate, effectively uses calculators, and spreadsheet, graphing, or discipline specific software to communicate quantitative information.
- Organizes, appropriately uses, and clearly communicates quantitative information.
- Shows a refined sense of effective ways to present quantitative information for a specific audience.
- Evaluates her own use of quantitative information and argument and the implications of her choices.

NSF Quantitative Literacy Grant Opening Workshop

1. How do you/could you provide students with opportunities to use quantitative information (collect it, organize it, detect significant patterns in it) to:
    - Build and support arguments,
    - Explore the way the world works,
    - Discover trends,
    - Draw conclusions about past or present phenomena,
    - Make predictions about the future based on trends?

Possible patterns
- Change over time
- Dimensionality
- Size
- Structure: part & whole
- Chance & uncertainty

2. How do you/could you provide students with opportunities to communicate about quantitative information:
    - Verbally (using language such as variable, average, etc. with accuracy),
    - Numerically (using spreadsheets, calculators, tables of data to make sense of numerical information),
    - Graphically (including qualitative graphs),
    - Symbolically/algebraically?

3. Form multidisciplinary groups, and share your brainstorming ideas. Set context for the course – e.g. level of student, topics covered, abilities offered. Listen for other QL possibilities as the teacher shares his/her ideas.

Reflections of NSF Quantitative Literacy Grant Project

Creating learning experiences

1. What did you learn about the role of quantitative literacy in the teaching and learning of your discipline?

2. How has your work affected your attitude or feelings about quantitative literacy?

Implementing learning experiences

3. What did you learn about students' readiness to do quantitative reasoning, the degree to which they view quantitative reasoning as an integral part of your discipline…

4. Does this suggest a new approach or strategy to use next time?

Inservice sessions

5. Which activities throughout the grant work were most helpful to your work?

6. If we were to hold a session for faculty beginning their adventure into QL, what should be done differently or what did we miss that should be included?

7. What topic(s) would you suggest for future inservice?

Inservices held

- QL gathering – a chance to talk with others who are teaching QL in their discipline course
- What did my students learn in the QL course?
- How do I give feedback – I need some language
- Graphing Excellence – beyond a pretty graph
- I need a little brush – up on QL myself

Quirk 8.08

Carleton College Quantitative Inquiry, Reasoning, and Knowledge (Quirk) Rubric for the Assessment of Quantitative Reasoning in Student Writing[1][2]

I. Paper identification code: student I.D.

II. Assignment assessment: call for QR? (0 = No, 1 = Yes, 5 = No assignment present).

III. Potential relevance of QR to paper: (0 = None/Incidental, 1 = Yes peripheral, 2 = Yes central).

-***NOTE***: This is a reader's assessment of the *potential* contribution of quantitative information to the paper based on the stated and implied goals of the paper itself; it is *not* an assessment of the specifications of the assignment.

None or incidental: **no potential uses of numbers or miscellaneous uses only**.

-e.g., An examination of the role of Confucianism in the downfall of the Han dynasty for a History course.
-e.g., A comparison of the depictions of Lucretia in paintings by Rembrandt and Gentileschi for an Art History course.
-e.g., A consideration of whether realist paradigms in Political Science make sense of Israeli and Palestinian conflicts and peace efforts.

Peripheral: **potential uses of numbers to provide useful detail, enrich descriptions, present background, or establish frames of reference**.

-e.g., A Psychology paper tracing possible psychogenic pain mechanisms that discusses the incidence of psychogenic pain in an opening paragraph.
-e.g., An evaluation of the nature of community in a contemporary mall observed for an American Studies course that discusses the popularity of malls in an opening paragraph.
-e.g., An account of the role of the Bible in the lives of slaves and slaveholders for a Religion course that presents, as background, common religious beliefs of Africans brought to America and the extent to which slaves later became Christians.

Central: potential uses of numbers to address a central question, issue, or theme.

-e.g., An evaluation for a Sociology course of the deterrent effects of capital punishment on violent crime.
-e.g., A lab report for a Biology course on allelic frequency in two populations of gall fly larvae to assess potential genetic variation and physical location differences in gall flies.
-e.g., An analysis for an English writing course of whether the 2001 No Child Left Behind Act benefits America's education system.

IV. Employment of QR: (0-4, where 0 = Not at All, 4 = Extensively).

-***NOTE***: This is *not* a rating of the quality of the QR shown; it is an assessment of the degree to which *explicit* numerical information or reasoning with quantitative information is present.

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[1]Carleton's Quantitative Inquiry, Reasoning, and Knowledge (Quirk) Initiative is supported by grant P116B040816 from the Fund for the Improvement of Postsecondary Education (www.ed.gov/FIPSE), U. S. Department of Education.

[2]For additional information on Carleton's Quirk initiative, see http://www.go.carleton.edu/quirk.

V. Problematic characteristics of QR present in paper: (0 = No check, 1 = Check).

-***NOTE***: Check an item *only* if the reader judges it to be a noticeable shortcoming of the paper. For example, the writer might not describe the data collection methods behind all quantitative information cited, but only check this if the failure to do so detracts significantly from the reader's understanding of the information presented.

VI. Overall assessment of QR employed in paper: rate *each* of the variables Implements, Interprets, and Communicates (1-4, where 1 = Inadequate, 2 = Adequate, 3 = Proficient, 4 = exemplary).

-***NOTE***: These three assessments reflect criteria appropriate to the relevance—peripheral or central—of the QR shown, as specified below. The number assigned represents an *overall* assessment of the uses of QR in the paper for peripheral or central purposes.

Peripheral uses of QR:

Implements competently: Accesses relevant and sound quantitative information. Demonstrates scholarship by citing informational sources and, where warranted, by evaluating sources.

Communicates clearly: Presents quantitative information in easily understood terms and/or in informative graphics. Provides sufficient information to determine units of measurement and magnitudes. Defines unfamiliar or ambiguous terms. Employs maximally appropriate precision.

Interprets effectively: Discusses how quantitative information illuminates a phenomenon or establishes a meaningful context. Identifies key points and explicates central comparisons.

Central uses of QR:

Implements competently: Selects appropriate quantitative methods for addressing questions. Accesses relevant and sound quantitative information and demonstrates scholarship by citing informational sources and, where warranted, by evaluating sources, OR generates and presents relevant quantitative information using sound data collection and analysis methods.

Communicates clearly: Presents quantitative information in easily understood terms and/or in informative graphics. Provides sufficient detail on quantitative findings to allow a reasonable reader to recognize and evaluate what was done. Provides sufficient information to determine units of measurement and magnitudes. Defines unfamiliar or ambiguous terms. Employs maximally appropriate precision.

Interprets effectively: Identifies key numerical findings. Evaluates findings in light of relevant standards and criteria. Relates numerical evidence to previous findings and central issues. Cites numerical evidence when addressing the conclusions of the paper. Weighs strengths and weaknesses of the quantitative methods and findings discussed. Acknowledges uncertainties.

Quantitative Reasoning in Student Writing Rating Sheet

I. Identification. **Student I.D. #: _____** **Reader I.D. #: _____**

II. Does the assignment explicitly call for the use of QR in the paper?

___ YES **___ NO** **___ NO ASSIGNMENT PRESENT**

III. Is QR potentially relevant to this paper? [rate potential contents of paper, not the assignment]

___ NO or incidentally only **___ YES, but peripherally only** **___ YES, centrally**

IV. **Does the paper, in fact, employ quantitative reasoning?** [**See**: "Employs QR Criteria";
Note: This is *not* a rating of the quality of the QR shown; it is an assessment of the degree to which QR is present.]

___ rating of 0-4, where 0 = not at all and 4 = extensively.

V. Problematic characteristics of the QR present in the paper: [check all that apply]

___ Uses ambiguous words rather than numbers.

___ 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 unwarranted 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.

VI. OVERALL ASSESSMENT of QR *actually employed in paper*:
[rate ***each*** of the following using 1-4, where
1 = Inadequate 2 = Adequate 3 = Proficient 4 = Exemplary;
review attached criteria]

___ Implements Competently **___ Interprets Soundly** **___ Communicates Clearly**

Generating Interdisciplinary Institutional Buy-In: A Quirky Approach

http://serc.carleton.edu/quirk/index.html

Neil Lutsky, Carleton College
nlutsky@carleton.edu

I. Framing QR broadly: Quantitative reasoning in the construction and evaluation of arguments.

See Lutsky (2008) in Arguing with Numbers: A Rationale and Suggestions for Teaching Quantitative Reasoning through Argument and Writing. In B. L. Madison & L. A. Steen (Eds.), *Calculation vs. Context: Quantitative Literacy and it Implications for Teacher Education.* Washington, D.C.: Mathematical Association of America.

Example: Writing with Numbers workshops

http://serc.carleton.edu/quirk/CarletonResources/WritingWithNumbers2WS.html

II. Involving academic support staff: Institutional research, informational technology, and academic librarians.

Example: Start Seeing Numbers workshop

http://www.carleton.edu/departments/LIBR/startseeingnumbers/index.html

III. Attracting broad faculty interest and participation: Workshops to introduce and support faculty appreciation, understanding, and uses of QR.

Example: Quantitative Reasoning University

http://serc.carleton.edu/quirk/CarletonResources/QRU.html

IV. Infusing QR across the curriculum: First year seminar and course revisions.

Example: Measured Thinking first year seminar.

http://serc.carleton.edu/quirk/courses/measured_thinking.html

Generating Interdisciplinary Institutional Buy-In

Caren Diefenderfer, Hollins University
cdiefenderfer@hollins.edu

General Education at Hollins University
Education through Skills and Perspectives (ESP)
Fall 2001

ESP Skills	ESP Perspectives
Writing	Aesthetic Analysis
Oral Communication	Creative Expression
Quantitative Reasoning (q and Q)	Ancient and/or Medieval Worlds
Information Technology	Modern and/or Contemporary Worlds
Applied Research	Social and Cultural Diversities
	Scientific Inquiry
	Global Systems
	Languages

Additional information available at http://www1.hollins.edu/depts/qr/index.html and http://www1.hollins.edu/homepages/hammerpw/qrhomepage.htm

Current Courses that meet the Q guidelines

Biology:	Ecology
Business:	Investments; International Finance; Corporate Finance
Chemistry:	General Chemistry I and II; Principles of Chemistry; Experience Chemistry; Analytical Chemistry
Classics/Art:	Ancient Art
Computer Science:	Computer Science I
Communications:	Research Methods in Communication
Dance:	Multimedia; Sound Design
Economics:	Economics of Health Care; Public Finance; Money, Credit and Banking; Macroeconomic Theory and Policy
English:	New Media and Literature
Environmental Studies:	Environmental Analysis
History:	The Renaissance; American Social History; European Empires
Humanities:	France and the French
International Studies:	Global Systems; French for International Business
Mathematics:	Mathematical Modeling in Today's World: Precalculus; Intuitive Calculus; Calculus I and II; Linear Algebra
Music	Structure and Chromatic Harmony
Philosophy:	Symbolic Logic
Physics:	Physical Principles I and II; Analytical Physics I and II
Political Science:	Research Methods in Political Science; International Political Economy
Psychology:	Analysis of Behavioral Design; Human Memory
Sociology:	Methods of Social Research
Spanish:	Latin American Culture and Civilization
Statistics:	Introduction to Statistics; Statistical Methods

Former Courses

History	France Since the Revolution
Sociology	Sociology of Health, Illness and Medicine
Theatre	Lighting Design; Scene Painting
Women's Studies:	Women and Economics

The Quantitative Reasoning Program at Hollins University - A Timeline of Events

Year	Event	Involvement	Description
1996	Idea for an interdisciplinary QR program	2 faculty members	Wrote a proposal and sent it to the strategic planning committee
1997	SACS Reaccreditation issues	Mathematics Department	VPAA asks the math department for a plan to meet SACS criteria The math department suggests a two step QR program, similar to the one at Wellesley.
1998	q becomes a graduation requirement	Faculty vote	Incoming students are given a qr assessment and students are either declared "q" proficient or are placed into "An Introduction to Quantitative Reasoning"
1998-1999	Sowell Faculty Development group	10 faculty members	Faculty members develop possible qr modules
1999-2000	Sowell Faculty Development group	20 faculty members	Faculty members read "Why Numbers Count"
2000-2001	NSF Faculty Development Grant	Campus wide events	Four visiting scholars/public lecture/faculty workshop 20 faculty members participate in Hollins led 4-day sessions to develop Q projects
2001	Q becomes a graduation requirement	Faculty vote	ESP Gen Ed program Two quantitative reasoning graduation requirements Hollins offers roughly 30 Q classes
2003 2004	PREP Summer workshops	4 presenters	Work on new Q projects Revisions to existing Q projects
2003	Hire Director of QR	Faculty/Admin position	Formalizing the QR tutor program Part-time faculty (math department)
2004	Pilot Site for Bookman/Ganter NSF Grant	8 faculty members	Faculty members develop "Guidelines for a Q project" and "Guidelines to Assess a Q project"
2004	Center for Learning Excellence	Writing & QR tutors	Common location
2004	Completion of the QR monograph	3 faculty members	Overview of the Hollins QR Program to share with others
2005	PREP Summer workshop	2 presenters	Macalester College
2006	Three "q" classes	Mathematics Department	Math 100 / Intro to QR Math 105 / QR in Today's World Math 130 / Math Modeling – Precalculus 1
2007 2008	Pilot site for Madison NSF Grant	Two sections of Math 105	Approaching quantitative reasoning via news articles
2007	Online placement	Incoming students	Revision of math placement and qr assessment

Guidelines to Consider

Build a program that fits your campus culture and style

Start small and dream large

Secure administrative support

Secure funding

Have a plan to sustain the program

Lessons Learned

Schedule multiple events

Allow faculty members to “buy in” at different levels

Proceed slowly and be patient

Dorothy Wallace and Kim Rheinlander from Dartmouth created this three-part worksheet for the 2004 PREP QL workshop. It was a successful way to get things started and we hope it will help your group focus on things that will be important for your own institution. Please complete these questions/activities as a group.

Clarifying QL in practice

Who is in your group?

Describe your institution, including its strengths and weaknesses.

Which of the given QL/QR definitions seems to describe what you would like QL/QR to be at your institution?

Clarifying QL in practice: Setting specific goals

What kinds of understanding, skills, ways of thinking, would you like your students to be able to have or do, that they seem unable to do at present?

Clarifying QL in practice: curriculum

Choose a current course that might address the goals you have identified and discuss some possible activities or assignments for this course that would help students to become stronger with quantitative analysis.

List ways in which you would need to modify or supplement the current course in order to meet these goals.

Clarifying QL in practice: Large scale strategies

The purpose of this section is to strategize about how to make QL a central issue at your institution.

List five (or more) individuals at your institution who would be interested in QL issues and curriculum change.

What would be the best way to gain the support of these individuals?

How will QL fit most naturally into your institution?

What are the first steps you can take to make this happen?

HANDBOOK FOR TUTORS
QUANTITATIVE SKILLS PROGRAM

TABLE OF CONTENTS

Tutor Training Spring '08
Saturday 1/26 (new Q-tutors only)

1. **Sign In [in Kanbar 107]**
   - training sign in sheet
   - tutor contract
   - name tags
   - agenda
   - pencils

2. **Introductions**
   - me
   - tutors: name, class year, tutoring assignment/area, home country/state, semester break activity
   - overview: today: a.m. admin/process matters
     tutoring – learning styles;
     p.m.: IT and group role playing, orientation in Center
     on Sunday : exercise on reading a Q-textbook; interaction with other q-tutors, opportunity for Q&A

3. **Administrative/Handbook Matters**
   (tutors picked up handbook prior to training; familiarized themselves w/contents)

QUIZ	LWK
Self correct	Make dotplots for #4
Some discussion	Talk about "assignment process for Groups and Tutorials
	Time Pro (see Bonny for forms/how to use)

4. **Learning Styles and Strategies**
   (students have taken Felder on-line assessment; brought results with them)
   assessment available at:
http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSpage.html
   - have style headings on white board (make a dot plot)
   - be aware of own style; also realize other styles may differ from yours (maybe your tutee's);
     not right/wrong, smart/dumb, good/better
   - scale is a continuum – many people benefit from a combination of presentations (learn from both)
   - exchange "strategies to become a more efficient learner" under headings
   - if encounter a student whom none of your strategies seem to help; who is having difficulty learning [and especially if organization, reading, planning, etc seems to be an issue] – a referral to the Baldwin Center in the Center could be beneficial

5. **Video of Individual Tutoring**
   (show a segment of the North Carolina State tutoring videos)
   brief discussion – what did you observe?

LUNCH [ON THEIR OWN]
MU 11:00-12:30 brunch
Thorne 11:00-1:30 brunch

6. **Individual Tutorial Role Play (2 problems-on pink/lavender pages; with the "student" displaying some "challenging behavior/learning style difficulties))**
   - students in pairs
   - have calculators available
   after each discuss
   - type of student in case #1 – strategies for dealing with
   student switch roles
   - type of student in case #2 – strategies for dealing with
   - use Handbook C-11, C-15, C-17 after above discussion

7. **Individual Tutoring Scenarios**
   Various personal scenarios with strategies for each
   - Students in pairs
   - Hand out scenarios-(4 at a time; 2 pairs)
   - Wait to look at until told
   - Tutee read – tutor respond; reverse roles & repeat
   - Analyze Q & A's – LWK solicit by "color"
     What is student saying? What is the issue?
     What are some good responses?
   - REPEAT with 2nd set

8. **Center Orientation**
   - Directors/offices/programs
   - Forms/Handouts-see shelves [same as in handbook section D; pick up whenever/whatever is helpful]
   - Study/tutoring areas - use space for IT's, resources, library-conf. room for IT with 2 or 3 students; also 2 rooms upstairs [talk to Bonny to reserve those 2 spaces]; CLEAN UP!
   - Resources: calculators, chem. mol. Kit; ref books
   - hours open (9am to 5pm Mon-Fri; 7 to 10 Sun-Thurs)

9. **Group Role Play-** 2 planned scenarios
   Train problem; Admissions problem [regroup students between problems; assign new "leaders"
   - Have 4 groups ["students" in group have specific "difficulty" to role play in group]
   - Remind tutors that they are TUTORS NOT TEACHERS
     Try to get the group to work together; guide/prompt as helpful
   - When done, identify "types" of students – strategies for dealing with

10. **Questions**
    - have students write down any questions that they would like answered during the training session tomorrow (no names required) – on file cards

11. **Evaluation**

Tutor Training Spring '08
Sunday 1/27 (all tutors)

1. Sign In (Kanbar 107) **and Introductions**

- name tags
- sign-in sheet
- tutor contracts (if not on Sat or in fall)
- HR forms (get from Bonny-only if not in F'07)
- study group listing (proof; time/location if know)
- agenda
- pencils
- me-welcome back; because of large number ask students to introduce themselves to one-another when we break into smaller groups a bit later

2. Administrative/Handbook Details

- for continuing tutors, be sure you have current handbook
- referrals: Baldwin, Writing, ESL
- on-line logs: I will send you the link [to group leaders on Monday; to IT's as assigned]; be sure to send me a log after each session -these feed into a recording system; log link was changed at end of last semester –use new only
- I am going to email all classes with; all SG leaders should meet with class; send class regular emails regarding time/location of group meetings throughout the semester
- Mid-semester check-in dates
- watch your emails – my primary contact with you; stop by my office "whenever"

3. Reading a Quantitative Textbook

Note: this exercise was adapted from one *in Learning to Teach & Teaching to Learn Mathematics: Resources for Professional Development* (see resource bibliography)

Goals

- To identify the function of reading the textbook within the framework of a course
- To understand tutoring behaviors that encourage/discourage students' reading of textbook
- To identify techniques for reading quantitative textbooks and discuss ways to transmit these techniques to tutees

A. Reading the Textbook and Course Expectations? {all in one room}

1. What does the Professor mean when s/he says "Read the Book"?
   - use yellow handout; have tutors circle "to the best of their knowledge"
   - suggest that tutors may want to talk with course professor regarding his/her intentions regarding reading assignments
2. In general, why is it important for students to "Read a Textbook"?
   - have tutors suggest reasons
   - supplement tutor listing with my listing (if needed)

B. Tutorial Behaviors to Encourage Students' Textbook Reading

See Mini-Group Leader guidelines

C. Specific Techniques Students use When Reading a Textbook

2. Solicit techniques tutors use when reading a text in their tutorial areas
   supplement with my listing (if needed)

Paired Reading activity {have students paired prior to training; give each pair 2 different readings which are likely to be unfamiliar to the reader)

General Directions

I will be handing out Q-text to each of you. Read your material employing any reading techniques appropriate (until I stop you); I am not concerned with whether or not you understand the material or even finish it; you are to think about the techniques you would use as a student and also that you would recommend to a tutee who has never seen the material and who has a weak preparation for it

a. Pair the students and hand out the material
b. After 10-15 minutes, Stop the "silent reading"
   - One person in each pair, now read the section aloud, starting at the beginning; pause in your reading to explain to your partner the technique you employed
   - The listener (tutor) now may make any suggestions/additions that s/he would have employed in reading this material
c. After @10 mins, STOP and REVERSE ROLES (repeat "b")
d. All Together -have tutees report on helpful techniques utilized

Photos (outside)

4. First Sessions/Questions and Answers

- group students by departments
- have "experienced tutors" tell how they prepare/announce/conduct first group or tutorials
- encourage new tutors to ask any questions they have about these first sessions
- address new tutor questions from Saturday
- continuing tutors offer any suggestions you have not already covered
- each group make a list of at least "three tips" to share with larger group
- share- all together back in 107
- any remaining questions

5. Evaluations

WHAT WORKS - A PKAL ESSAY

COMMUNICATION, COMMUNICATION, COMMUNICATION: CONNECTING ASSESSEMENT TO ENHANCE STUDENT LEARNING

Donna L. Sundre
Executive Director for the Center for Assessment & Research Studies
Professor of Psychology
James Madison University

In the real estate profession, the mantra is "location, location, location." In most other pursuits, an advisable mantra might be "communication, communication, communication." The prudence of academic leaders adopting such a mantra in the instance of assessment of student learning is easily illustrated by even the most fleeting review of institutional case studies where false starts, strong beginnings accompanied by equally strong fizzles, and outright "no-go's" are evident.

In the vast majority of such cases, communication was a prime suspect in what might be termed "institutional sabotage." Sometimes, this sabotage occurs unintentionally, in others with quiet subtlety or benign neglect. Strong assessment programs are nurtured and sustained over time with careful, clear, continuous communication that welcomes dialogue, is multi-directional, and invites broad participation. Clear communication, coupled with consistent action, is the foundation for the building of trust that is key to a successful assessment program.

Trust is the lubrication that makes it possible for organizations to work.

— Warren Bennis

If assessment of student learning is to succeed, it must be clearly communicated to each of the constituents- students, faculty and administrators- that assessment makes a positive contribution to their work. This suggests an important theme for a strong communication strategy: constructive intentionality. When there is collective understanding that something is being undertaken for positive purposes, the potential for damage (or an outright "no-go") is greatly reduced. When positive benefits are not communicated and discussed, the community can feel threats, real or perceived.

Trust not the horse, O Trojans. Be it what it may, I fear the Grecians even when they offer gifts.

— Virgil (attribution)

Academe is a highly political environment populated by intelligent, autonomous stakeholders. The very word "assessment" has several potentially rival meanings for different constituents. Faculty, for example, might hear "audit," when assessment is uttered by an administrator. Academic administrators might be equally concerned by the connotation of "accountability" to external constituents when assessment is under consideration.

KEY SUGGESTIONS TO CATALYZE COMMUNICATION:

- clear communication of intentionality
- broad involvement
- clear communication of the process of planning
- a formal policy statement
- institutional context.
- wide-spread support
- adequate resources.

WHAT WORKS - A PKAL ESSAY

COMMUNICATION, COMMUNICATION, COMMUNICATION: CONNECTING ASSESSEMENT TO ENHANCE STUDENT LEARNING

Particularly when presented as a mandate from the public to "improve the quality of education," many leaders legitimately assume a defensive posture, if not feel outright rage: the implication is a lack of quality, a failure to recognize competent stewardship and a disregard for evident outstanding teaching, learning and service to the institutional mission.

Thus most externally-imposed assessment programs result in failure because they tend to breed a "compliance mode" of participation, rather than meaningful engagement throughout the campus.

What can be done? How can the academic community build trust in an assessment program by clear communication that leads to a shared vision and commitment to the process? Here are some suggestions, not an exhaustive list, but offered to catalyze communications on campuses exploring new or reshaped assessment programs.

Clear communication of intentionality.

Begin with a strong statement of why an institution-wide assessment program is to be established and how it will serve the mission of the institution.

Broad involvement.

Convene a task force of all campus constituents, including faculty, academic administrators, student affairs administrators and students. All have important contributions to make and any group that is left out- formally or informally has the power and autonomy to sabotage the very best efforts of others.

Clear communication of the process of planning.

The task force should establish a mechanism to keep the larger community informed about and involved in the process and progress of planning an institution-wide assessment effort.

Begin with a strong statement of why an institution-wide assessment program is to be established and how it will serve the mission...

A formal policy statement.

The task force should craft a formal policy statement that outlines how constructive assessment serves the institutional commitment to student growth and development, and how it offers further enhancement of a campus community with shared values, with leaders assuming their intellectual and professional responsibility. Drafts of the statement can be vetted by the larger community, as appropriate.

Faculty members and other professional staff are legitimately skeptical in regard to campus-wide initiatives that seem to have no clear pathway or goal. Most have survived past efforts that have failed and believe they can easily outlast another.

This policy statement should demonstrate institutional commitment at all levels. How the assessment data and outcomes will be used, perhaps for program review or resource allocation and reallocation, needs to be stated explicitly in the policy statement.

Institutional context.

Every institution-wide assessment program will take time to 'get it right.' This is not an easy task; there are no easy formulas, and the complexity of the task cannot be understated.

Further, every campus needs to shape an assessment approach that fits its particular circumstances, even though much can be learned from the work of colleagues.

One of the strengths of American higher education is its diversity and recognition of this strength is critical if local assessment efforts are to succeed.

Take time to:

- *talk about program goals and objectives*. Ask about the goals and objectives of the academic programs. Ask how you want students to change while they are on your campus, what skills and competencies you expect them to achieve.

  Though this may generate only a few sheets of paper per program and be an arduous undertaking, the process of talking about what is important to the community in regard to student learning is rewarding.

WHAT WORKS - A PKAL ESSAY

COMMUNICATION, COMMUNICATION, COMMUNICATION: CONNECTING ASSESSEMENT TO ENHANCE STUDENT LEARNING

- *design assessment methods appropriate for your goals and objectives*. Gather information and materials about current assessment instruments, those currently used by faculty on your campus and those developed elsewhere.

  Most likely, in their current form, they will not fully serve your needs. It takes time to design assessment plans with the right content. It takes even more time and effort to create and test a method for assessment that works for your community.

- *consider congruence*. Communicate and demonstrate the congruence of assessment methods with course content, with instructional methods, and with student opportunities to learn and practice the skills and competencies that are your goals for their learning.

  This is a key part of the communication effort, because without linking student curricular and co-curricular experiences with objectives of specific courses and programs, assessment will occur in a void and results will not be used.

- *test components*. There are many distinct parts to a successful assessment effort:
  - goals and objectives
  - measurement methods
  - data collection, analysis, and interpretation
  - reporting of information to relevant stakeholders.

  The value of each component to the success of the whole must ultimately be clearly understood by all, through a process of piloting and refining, and communicating the outcomes of those efforts.

- *review regularly*. Assessment programs must be expected and allowed to evolve, based on the experiences of the various stakeholders.

  Engage the community in regular discussions about the opportunities and obstacles to building a robust assessment program, and about ways to inform and improve assessment practices on your campus.

- *assess systematically and continuously*. Build a systematic agenda for assessment of student learning over the long-term; do not consider a one-shot effort. Without a continuous flow of data, patterns about student learning cannot be discerned.

  Seeing improvement in student outcomes over time is the lifeblood of assessment programs in higher education. This commitment to the long-term should be part of the policy statement and clearly communicated to faculty, administrators, and others involved from the beginning of the planning process.

Wide-spread support.

It is imperative to have visible and consistent support for the assessment program by senior administrators, but it is equally important to have a balance of support from faculty and other staff.

To build confidence and trust, administrators should follow the "Goldilocks Rule:" their support and ownership should be neither too strong nor too weak- it must be just right. A good administrator knows the difference, and knows how to gain faculty's trust and ownership through a meaningful charge and consistent support, both well communicated.

Faculty need to test and to develop confidence in the practice of assessment on your campus. Similarly, students must be actively involved, because any lack of student understanding about how assessment contributes to the quality of their learning can lead to disastrous outcomes, such as unmotivated participation in the process.

Adequate resources.

While the benefits of vibrant assessment programs are well-known, it is not always understood that they require many resources: of time, energy, materials and well-qualified professional personnel.

Many campuses can relate stories about painful and unproductive episodes of attempting assessment, due most often to inadequate resources.

WHAT WORKS - A PKAL ESSAY

COMMUNICATION, COMMUNICATION, COMMUNICATION: CONNECTING ASSESSEMENT TO ENHANCE STUDENT LEARNING

One responsibility of the assessment professional on a campus is to build and sustain the communications process that results in the provision of adequate resources. At every stage, do not underestimate or ignore the importance of communication.

While it may be tempting to put program development on a fast track, the ultimate benefits of the process and the program will be severely diminished.

Without active communication and engagement with honest and direct realignment, minor setbacks will lead to, and accelerate, the diminution of trust needed to sustain a strong program.

With active communication about each observed success as well as the minor setbacks, however, the trust necessary for a meaningful assessment program to evolve will appear. ■

Assessment at James Madison University

James Madison University has developed an institution-wide assessment program that crosses academic and student affairs, recognizing a common interest in the development of the student as a whole individual.

The program, which began in the late 1980's, includes assessment at four stages:

1. Matriculating student assessment during summer orientation for all entering freshman

2. Mid-point assessment of all undergraduates in early February

3. Assessment of graduating seniors in conjunction with their academic major

4. Regular surveys of alumni.

Assessment covers general education, the major, and programs sponsored by student affairs. The program is designed to evaluate learning outcomes by establishing a baseline for entering freshman and following their development over time.

For general education courses, assessment is developed from learning outcomes set and measured by faculty.

From the James Madison University experience, we believe the following are characteristics of an effective assessment program:

- clear, specific and measurable objectives for student learning at the level of department and course that fulfill the intent of institutional goals
- multiple methods (selected, developed or adapted) to properly assess each of the objectives for student learning
- regular procedures to scrutinize the reliability and validity of the assessment methods
- a proper design to ensure that internal and external threats to the validity of the assessment program have been minimized
- agreed-upon standards for assessment such as "cut-off " scores for student performance
- carefully planned and monitored procedures to collect assessment information, including suitable and comprehensive statistical procedures
- a plan for interpreting assessment results (outcomes concerning student learning) relative to institutional goals for student learning
- a means to gather evidence of curricular, instructional, and/or modifications to serving students in response to the interpreted assessment results
- a means to gather evidence that resources have been allocated or reallocated in response to the interpreted assessment results
- regular, accurate and objective reports to the community about statistical findings and evidence of the use of such findings to shape institutional future
- continuing leadership of administrators, faculty and staff engaged in ongoing discussions about the assessment of student learning
- trustworthy and competent staff responsible for conducting assessment, so that findings achieve maximum credibility, acceptance and trust of the broad campus community.

WHAT WORKS - A PKAL TOOL

THE PKAL PLANNING PROCESS

Jeanne L. Narum
Director
Project Kaleidoscope

This planning tool emerged from the 2004-2007 PKAL Leadership Initiative (LI) an NSF-funded initiative.

The intent of this initiative was to nurture campus-based leadership teams tackling the interesting and challenging work of building and sustaining robust STEM learning environments for undergraduate students.

Reflects contemporary pedagogical approaches

Goal: Tackling the work of transforming undergraduate STEM with approaches and tools of STEM professionals.

Strategies:

- Assemble a leadership team that includes persons with diverse interests, experiences and expertise, each capable of informing, influencing, shepherding and supporting the process and outcome of the planning.
- Analyze present circumstances and context, defining the broad nature of the challenges and opportunities facing the community.
- Identify key questions, shaping an "agenda for action" to answer them that takes advantage of the widest range of available experience, expertise and resources.
- Move from analysis to action.
- Reconvene regularly, sharing emerging answers, insights and resources of potential value; revisit the questions, agenda for action and process.
- Communicate clearly, broadly and often, building wide-spread ownership in the process and the outcome of the planning.

Centers on student learning

Goal: Serving a vision that all 21st century undergraduates move from campus to the world beyond the campus well-equipped with deep understanding about contemporary scientific and technological issues and with the skills, capacities, and willingness to use that understanding in addressing those issues as citizens and in the workplace.

Strategies:

- Understand who your students are, what they bring to and gain from their current STEM learning experiences, their learning potential and career aspirations.
- Translate research on how people learn (HPL) into critical questions to be addressed in the planning process on your campus.
- Examine each part of the institutional infrastructure to determine if and how it contributes to strengthening student learning in STEM fields.
- Focus on the future, on the world in which your students will live and work upon graduation, as well as on the changing student demographics in our country.

WHAT WORKS - A PKAL TOOL

THE PKAL PLANNING PROCESS

Develops leaders and an institutional culture of leadership.

Goal: Generating a visible and evolving cadre of persons in positional and non-positional leadership taking responsibility for shaping an institutional vision and achieving a culture in which that vision can be realized.

Strategies:

- Understand both the leadership culture of your community and the current and anticipated roles and responsibilities of your community with opportunity and responsibility to foster meaningful and lasting change.
- Translate leadership theories into the critical questions about the role of leaders and the culture of leadership within your community that must be addressed in the process of change.
- Examine where and how policies, programs and practices of your community reflect intentionality in identifying, nurturing and celebrating the work of transformative leadership.
- Build an infrastructure for sustaining a culture of leadership within your community over the long-term.

Focuses on *what works*

Goal: Building a collaborating, problem-solving community within and beyond individual colleges/ universities/disciplinary societies/ stakeholder institutions that are taking leadership responsibility for meaningful and sustainable transformation of undergraduate STEM at the local and national level.

Strategies:

- Understand current and anticipated challenges and opportunities affecting the work of those responsible for ensuring a robust 21st century STEM learning environment for undergraduates in American classrooms and labs.
- Investigate the work of pioneering individuals and institutions meeting those challenges and capitalizing on those opportunities.
- Distill their experience to determine what works (how, why and for whom); then translating resulting data and information into theoretical guidelines and practical tools that serve the broader STEM community of innovators and adapters.
- Orchestrate a coordinated set of activities to inform the broader STEM community about how to begin, implement, and assess a process of change that: focuses on what works; engages leaders within an institutional culture of leadership; tackles change initiatives with approaches and tools of STEM professionals; and centers on student learning. ■

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◆

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Presenter Biographies

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David Bressoud is Professor of Mathematics and Director of the Quantitative Thinking program (http://www.macalester.edu/qm4pp/index.html) at Macalester College. He also currently serves as President-Elect of the Mathematical Association of America. He was a Peace Corps Volunteer in Antigua, West Indies (1971-73), received his Ph.D. (1977) from Temple University where he studied with Emil Grosswald. He taught at Penn State from 1977 to 1994, becoming a full professor in 1986. He has held visiting positions at the Institute for Advanced Study (1979-80), University of Wisconsin (1980-81 & 1982), University of Minnesota (1983 & 1998), and the University of Strasbourg (1984-85). He has received the MAA Distinguished Teaching Award and the MAA's Beckenbach Book Award for *Proofs and Confirmations: The Story of the Alternating Sign Matrix Conjecture*. He has published over fifty research articles in number theory, combinatorics, and special functions, and his other books include *Factorization and Primality Testing* (1989), *Second Year Calculus from Celestial Mechanics to Special Relativity* (1991), *A Radical Approach to Real Analysis* (1994), and, with Stan Wagon, *A Course in Computational Number Theory* (2000).

Caren Diefenderfer has been a member of the Hollins mathematics department for over 25 years and was instrumental in establishing the Hollins QR program. She received her AB from Dartmouth College and her MA and PhD degrees from the University of California at Santa Barbara. She is currently the chair elect of the Special Interest Group of the Mathematics Association of America on Teaching Advanced High School Mathematics (SIGMAA TAHSM). She was the Chief Reader for the AP Calculus program of the College Board (2003-2007) and has also served as chair of the Special Interest Group of the Mathematical Association of America on Quantitative Literacy (SIGMAA QL). She was a member of the steering committee for the Mathematics Across the Community College Curriculum (MAC^3) NSSF grant and has been a campus consultant for numerous institutions as they implement QL/QR programs.

Nathan D. Grawe is Associate Professor of Economics at Carleton College and Director of the College's *Quantitative Inquiry, Reasoning, and Knowledge* (QuIRK) initiative. He earned his BA from St. Olaf College and his PhD in Economics from the University of Chicago. As Director of the QuIRK initiative, he leads Carleton's professional development and assessment activities relating to quantitative reasoning.

Rebecca Hartzler is the Dean for Science and Mathematics for Seattle Central Community College. She was the principal investigator for Washington State's Mathematics Across the Curriculum project from 2000-2005, and is a co-principal investigator for the American Mathematical Association for Two Year College's Mathematics Across the Community College Curriculum project. Both projects were funded by multiple sources: the National Science Foundation, Federal appropriations funding, Washington state funding and internal college funding. Over the past eight years these two projects have supported nearly 250 faculty across the United States in integrating mathematics into college curricula.

Mark Isaacson came to Augsburg in 1998 with a strong liberal arts background. He has a strong interest in the statistical side of business administration. Prior to joining Augsburg, he worked at Innovex Inc. in Maple Plain in various quality/engineering roles, including the launch of Flex Suspension Assemblies into high volume manufacturing. In this role, he traveled to Asia extensively and was involved in global engineering, development and customer service issues. His interests include quantitative problem solving, quality engineering and entrepreneurship. Isaacson is also helping to advise the Augsburg Business Club.

Linda Kirstein received a B.A. in mathematics from Bates College and an M.A.T. from The Johns Hopkins University. From 1973 to 2001 she held positions of Professor of Mathematics, Math Department Chair, and Vice President for Academic Affairs at Paul Smith's College in the Adirondack region of New York. During that time, she started a Math Lab utilizing student tutors, consolidated departmental tutoring into a Learning Center, and piloted reformed calculus and workshop statistics courses in which she worked with student tutors in a modified supplemental instruction format. Since 2003, Linda has been the Director of Quantitative (Q) Skills at Bowdoin College. In that position, she administered a Q-Skills assessment test to incoming students and met with the about 100 "low-scoring" students, out of classes of 480, each fall to discuss course options for strengthening their Q-reasoning and confidence. She provided support for all students enrolled in Q-courses by overseeing about 35 tutor-led study groups, some Q-workshops, and 50-70 individual tutorials each semester. She also worked with Bowdoin faculty to enhance their understanding of Q-skills and to encourage the inclusion of Q-material in their courses. Linda retired in June, 2008, and will be serving as a resource for Bowdoin's new Q-director in Fall '08.

Neil Lutsky is William R. Kenan, Jr. Professor of Psychology at Carleton College in Northfield, MN. He was the principal investigator on a grant from the Department of Education FIPSE program initiating Carleton's *Quantitative Reasoning, Inquiry, and Knowledge* (QuIRK) program. As part of this project, he developed a new course, *Measured Thinking: Reasoning with Numbers about World Events, Health, Science, and Social Issues*, to introduce first year students to quantitative reasoning and to involve those students in service learning projects that call upon their quantitative expertise. Lutsky earned his B.S. in Economics from Penn's Wharton School and his Ph.D. degree in Social Psychology from Harvard University. He is a past president of the Society for the Teaching of Psychology, a blue ribbon winner for jam at the Minnesota State Fair, and an avid if slow road bicyclist.

Bernard L. Madison is a mathematician and mathematics educator with experience in research, teaching, university administration, and science policy. He currently directs national efforts on assessment of student achievement (http://www.maa.org/SAUM), articulation between school and college mathematics, and on the mathematical education of teachers (http://www.maa.org/PMET). In addition, he is part of a team aiming at improving quantitative literacy education (http://www.woodrow.org/nced). Madison began his career at Louisiana State University where for 13 years he was active in publishing mathematics research and teaching. In 1979, he accepted the position as Professor and Chair of Mathematical Sciences at the University of Arkansas. Ten years later he was appointed Dean of the Fulbright College of Arts and Sciences at Arkansas, a position he held until 1999. During 2001 he is Visiting Mathematician at the Mathematical Association of America in Washington, DC. From 1985-90 he structured and directed Mathematical Sciences in the Year 2000 at the National Research Council, including the national colloquium, Calculus for a New Century. He has held several positions with the College Board's AP Program, including Calculus Chief Reader and member of the National Commission on the Future of the AP Program. He holds a bachelor's degree in mathematics and physics from Western Kentucky University and masters and doctoral degrees in mathematics from the University of Kentucky.

Cathryn A. Manduca is director of the Science Education Resource center at Carleton College. This center is engaged in several projects that support effective science education nation-wide, including development of an on-line community center for the Digital Library for Earth System Education, professional development workshops and on-line resources for geoscience faculty, and an interdisciplinary effort by the National STEM Education Digital Library to understand how faculty engage students with data in their courses. Manduca served as coordinator for the Keck Geology Consortium undergraduate research program from 1994-2000. She is Vice President for the National Association of Geoscience Teachers and has co-authored several reports mobilizing action in the geoscience and digital library communities: *Shaping the Future of Undergraduate Earth Science Education*; *The Digital Library for Earth System Education? A Community Plan*; *Pathways To Progress? Vision and Plans for the National STEM Education Digital Library*; and *Using Data in Undergraduate Science Courses*.

Suzanne Mente is the assistant director of Instructional Services and Quantitative Literacy Coordinator at Alverno College. She earned a Masters' in Mathematics from the University of Minnesota and has been teaching and writing curriculum at Alverno College for 20 years. As QL Coordinator, Sue was instrumental in the adoption of a graduation requirement for all students to demonstrate QL in discipline courses which celebrates its 10 year anniversary this year. Sue was also the primary author of three in-house published QL coursebooks used in all beginning level QL courses at Alverno. She continues to serve as a resource to faculty across the curriculum.

Jeanne L. Narum is Director of the Independent Colleges Office (ICO) and of Project Kaleidoscope (PKAL). ICO Director since 1988, Jeanne assists select liberal arts colleges in relations with federal agencies and programs. In 1989, she became the founding director of PKAL, an informal national alliance of educators, administrators, and other stakeholders working to strengthen undergraduate programs in mathematics, engineering, and the various fields of science. As PKAL Director, Narum has a variety of responsibilities, all focused on building leadership at the institutional and national levels to ensure that American undergraduates have access to robust learning experiences in STEM fields. Both ICO and PKAL responsibilities connect to Narum's commitment to higher education. She serves on advisory boards at the Center for Functional Nanoscale Materials and Systems (CREST) at Clark Atlanta University; the Puerto Rico Louis Stokes Alliances for Minority Participation (LSAMP); the College of Chemical and Life Sciences at the University of Maryland; and Research Corporation; she has also served on several task forces for the National Research Council. Narum has received four honorary doctorates, the most recent awarded by St. Lawrence University.

Carol Rutz has directed the writing program at Carleton College since 1997. Research interests include response to student writing, assessment of student learning, and assessment of faculty development. Among her publications are two co-edited volumes of faculty-written essays on teaching and learning at Carleton: *Reflections on Learning as Teachers* (2004, College City Press) and *Building Intellectual Community Through Collaboration* (2007, College City Press). She has been involved in Carleton's QuIRK Program through her teaching of QR in the context of writing seminars for first-year students, and she has been a presenter or co-presenter on topics combining writing across the curriculum, QR, and assessment in several national venues.

Milo Schield is Professor of Business Administration at Augsburg College. He has a Ph.D. from Rice University. He currently teaches critical thinking and traditional statistics. Milo is the Director of the W. M. Keck Statistical Literacy Project (www.augsburg.edu/statlit/). He developed and teaches a Statistical Literacy course that helps students interpret the statistics found in news stories, tables and graphs. He is working on a Statistical Literacy textbook. Last year he created over a thousand Moodle exercises for students in that course. During the past 10 years, he has written over 40 papers on statistical literacy and given talks in Australia, Japan, Brazil, South Africa, Spain, Sweden, Denmark, Scotland, Wales, England and the US. He has organized sessions on Statistical Literacy at the last 10 national meetings of the American Statistical Association. He is the web-master of the www.StatLit.org web site. Schield serves as Vice-President of the National Numeracy Network.

Lynn Arthur Steen is special assistant to the provost and professor of mathematics at St. Olaf College in Northfield, Minnesota. Steen has served as an advisor for Achieve, Inc. concerning K-12 mathematics, as executive director of the Mathematical Sciences Education Board at the National Academy of Sciences, as a member of the founding steering committee for Project Kaleidoscope, and as president of the Mathematical Association of America. He is the editor, co-editor, or author of many books on mathematics and education including *Calculation vs. Context* (2008), *Math and Bio 2010* (2005), *Mathematics and Democracy* (2001), *On the Shoulders of Giants* (1991), *Everybody Counts* (1989), and *Calculus for a New Century* (1988). Steen received his Ph.D. in mathematics in 1965 from the Massachusetts Institute of Technology.

Donna L. Sundre is the Executive Director for the Center for Assessment and Research Studies (http://www.jmu.edu/assessment) at James Madison University in Harrisonburg, Virginia. She is also a Professor of Graduate Psychology and teaches in the Assessment and Measurement PhD program. Her research and publication areas include assessment practice, examinee motivation, instrument development, and validity issues. She is a frequent presenter in assessment and measurement topics and has consulted widely with many higher education institutions and public and private agencies.

Christopher Tassava serves as the Associate Director of Corporate & Foundation Relations at Carleton College. In this role, he works closely with faculty and staff to pursue grant funding in support of projects ranging from institutional priorities such as the college's Quantitative Inquiry, Reasoning, and Knowledge initiative to the research projects of individual faculty members. Before coming to Carleton in October 2005, he earned a PhD in history from Northwestern University and taught history at Twin Cities colleges and universities.

Corrine Taylor is Director of the Quantitative Reasoning Program at Wellesley College. After graduating from the College of William and Mary in Virginia in 1988, she worked for three years as a strategic planning analyst for MetLife Auto & Home, where she honed her applied quantitative skills. In 1998, she received her Ph.D. in economics from the University of Wisconsin (Madison) and joined the faculty in Wellesley's Economics Department. Taylor teaches courses in quantitative reasoning, social science data analysis, statistical analysis of education issues, microeconomics, the economics of education, and public economics. Her research focuses on the economics of education, in particular, elementary and secondary school finance. In 2001 she became the first director of the College's QR Program. Taylor has led workshops, given invited lectures, and served as a consultant at other colleges, universities, and public school systems that are developing QR initiatives. She has served as president of the National Numeracy Network since the spring of 2007.

H. Leonard Vacher is Professor of Geology at the University of South Florida, where he has taught introductory geology, hydrogeology, and various courses in math concepts (more recently QL) for geologists. From the late 1960s to mid-1990s his research focused on Bermuda and other young islands of coral seas, culminating with publication of a thousand-page reference, Geology and Hydrogeology of Carbonate Islands. Since then his focus has been mainly a version of QL (and geologically, in the Karst Information Portal and geological information more generally). He wrote a column "Computational Geology" for the J*ournal of Geoscience Education* (1998-2005), received the *Neil Miner Award from the National Association of Geoscience Teachers* (2004), was a member of the founding board of the National Numeracy Network (2004), and now is PI of *Spreadsheets Across the Curriculum* (NSF DUE project) and a managing editor of NNN's journal, *Numeracy* (http://services.bepress.com/numeracy/).

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EVALUATION

2008 QuIRK Initiative Workshop co-sponsored by PKAL
Quantifying Quantitative Reasoning in Undergraduate Education:
Alternative Strategies for the Assessment of Quantitative Reasoning
Carleton College, Northfield, Minnesota
October 10-12, 2008

We appreciate your time and insights in completing this evaluation. We will draw on these comments when planning future events.

A. Rate your overall experienece of this workshop from 1-5 (1=strongly disagree and 5=strongly agree).

Experience	Rating
This workshop has deepened my understanding of QR's role in general education and in the major.	
This workshop deepened my appreciation for the challenges of assessing QR resulting from its interdisciplinary, contextual nature .	
This workshop provided our team an introduction to the range of QR assessment tools currently in use.	
At the workshop our team learned new ideas for developing effective QR programming, professional development, and/or student support.	
The workshop strengthened our institution's connection to the broader community of institutions seeking to improve QR among students.	

B. Rate the presentations from 1-5 (1=poor and 5=excellent; NA=not applicable).

Presentation	Style	Content	Discussion/ Interaction	Carry-Over to Home Campus	Overall Effectiveness
Plenary Session I: *The Quantitatively Reasoned Life* — Bernard L. Madison & Lynn A. Steen					
Cluster Group Meetings: *Exploring Goals*					
Plenary Session II: *Use, Misuse, and Missed Use of Quantitative Reasoning in Student Writing* — Nathan D. Grawe					
Birds-of-a-Feather Discussions					
Breakout Session I (*please indicate which breakout session you attended*):					
Cluster Group Meetings: *Next Steps: Strategies & Actions*					
Plenary Session III: *Challenges of Quantitative Reasoning Assessment* — Donna L. Sundre					

Presentation	Style	Content	Discussion/ Interaction	Carry-Over to Home Campus	Overall Effectiveness
Breakout Session II (*please indicate which breakout session you attended*):					
Breakout Session III (*please indicate which breakout session you attended*):					
Plenary Session IV: *Team Reports and Open Q & A* — Jeanne L. Narum					
Plenary Session V: *Building a QR Community: The Future of the National Numeracy Network* — Corrine Taylor & H. Leonard Vacher					

C. Please respond to the following questions:

1. Had your team been working together on curricular reform prior to the Workshop? In what way? Who else has been involved and for how long?

2. What specific preparations did your team make as a group for the Workshop? What specific questions did you bring?

3. Did your team work as a group during the Workshop? How?

4. How will your team work as a group after the Workshop?

5. What is the most important idea you will bring back to your colleagues?

6. Do you have suggestions about how PKAL can encourage teams to work more productively before, during, and after the workshop?

7. General Comments:

Carleton College's Quantitative Inquiry, Reasoning, and Knowledge (QuIRK) initiative desires to develop a campus-wide culture of appreciation for quantitative evidence in the evaluation, construction, and communication of arguments. With support from The U.S. Department of Education's Fund for the Improvement of Post-Secondary Education, QuIRK designed an assessment tool and crafted a model of professional development to support this vision. QuIRK is currently supported by the NSF and the W. M. Keck Foundation.

Project Kaleidoscope (PKAL) is a national alliance of individuals, institutions, and organizations engaged in the work of identifying and nurturing leaders assuming responsibility for undergraduate science, technology, engineering and mathematics programs (STEM). PKAL is a leading advocate in this country for building and sustaining strong undergraduate programs in STEM and focuses on building learning environments that attract and sustain undergraduate students to the study of STEM fields, and motivate them to consider careers in related fields. PKAL works to equip teams of faculty and administrators for leadership in reform at the local level, so that students and science are better served, as well as to encourage broad understanding of how strong undergraduate STEM programs serve the national interest. PKAL programs and publications spotlight successful efforts on campuses across the country in addressing current challenges facing higher education leaders, recognizing that in these challenges are also opportunities to shape the future.

We thank Carleton Dean Scott Bierman and the NSF for financial support for this workshop.

We thank Nathan Grawe (Director, QuIRK) and Jeanne Narum (Director, PKAL) for organizing the program.

We are especially grateful to workshop leaders:

- David Bressoud, Macalester College
- Caren Diefenderfer, Hollins University
- Nathan Grawe, Carleton College
- Rebecca Hartzler, Seattle Central Community College
- Marc Isaacson, Augsburg College
- Linda Kirstein, Bowdoin College
- Neil Lutsky, Carleton College
- Bernie Madison, University of Arkansas
- Cathy Manduca, Carleton College Science and Education Resource Center
- Suzanne Mente, Alverno College
- Carol Rutz, Carleton College
- Milo Schield, Augsburg College
- Lynn Steen, St. Olaf College
- Donna Sundre, James Madison University
- Christopher Tassava, Carleton College
- Corri Taylor, Wellesley College
- Len Vacher, University of Southern Florida

The QuIRK initiative has been supported by grants from the U. S. Department of Education Fund for the Improvement of Post-Secondary Education (#P116B040816), the National Science Foundation (#DUE-0717604), and the W.M. Keck Foundation. Any opinions, findings, conclusions or recommendations expressed are those of the grantee and do not necessarily reflect the views of the Department of Education, the National Science Foundation, or the W.M. Keck Foundation and you should not assume endorsement by the Federal Government or the W.M. Keck Foundation.

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