Quantitative Literacy Curriculum Innovation Community

Report and Recommendations

Curry College, 2011-2012

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Introduction

This document is a summary of the research, discussions, and recommendations of the Quantitative Literacy Curriculum Innovation Community of Curry College during the 2011-2012 academic year. Throughout this document we use the terms quantitative literacy, quantitative reasoning, and QR interchangeably. Additionally, our discussion regarding students should be taken as inclusive of Curry Students in general, including graduate students, continuing education students, undergraduate students, PAL students, commuters, and residents.

Key Recommendations

Throughout this document we make many recommendations for the improvement of quantitative literacy at Curry. Below are what we consider to be the key recommendations of this document and who we are making the recommendation to.

We, the QL-CIC, recommend that the:

- Dean appoint a task force to implement the establishment of a Quantitative Commons
- Mathematics placement/assessment be changed, as recommended by the math area
- Faculty Center host workshops on integrating QR into teaching
- Faculty Center call for and support Quantitative Enhanced courses
- Writing faculty create conscious expectation of clear QR in student writing
- Ed Tech Committee pursue establishment of a QR Learning Repository

Summary of the Quantitative Literacy CIC

The Quantitative Literacy Curriculum Innovation Community met 16 times during the 2011-2012 academic year, on Mondays from 12:30-2:00. We have approximately eight people actively engaging with the group, and our mailing list of faculty interested in QR has 24 members. The group has focused on understanding issues in quantitative reasoning, both in general and at Curry. Toward that end we have:

- Read a selection of background and research articles regarding quantitative reasoning, literacy, and numeracy. (See Reading List)
- Three members attended the Joint Mathematics Meeting, which held sessions on Quantitative Literacy (http://jointmathematicsmeetings.org/jmm)
- Three members attended the Edward Tufte seminar on Presenting Data and Information
- Determined Quantitative Reasoning definition and learning objectives (See Appendix)
- Made recommendations to Gen Ed (See Appendix for Gen Ed communications)
- Compiled a Learning Repository of QR materials (See Appendix)
- Presented a QR overview at the Curriculum Innovation Community Holiday Gathering (Handout) and the Spring Celebration Dinner.
- Conducted a survey of the faculty regarding their opinions and use of QR in the classroom.
- Met with PAL director, Joe Cullen, to learn about dyscalculia and discuss quantitative reasoning as it relates to PAL. (See Dyscalculia Handout.)
- Met with Director of Academic Enrichment, Ned Bradford, to discuss ideas and issues involved in developing a Quantitative Commons at Curry.
- Met with members of the Writing Across the Curriculum CIC to discuss embedding QR in written assignments.
- Examined and discussed mathematics placement/assessment and the mathematics area's assessment proposal.
- Made recommendations regarding QR at Curry (i.e. this document).

Definition and Learning Objectives

Quantitative Literacy (Numeracy) and consequently Quantitative Reasoning, are vital competencies for success in school, career, and functioning in society. The QL-CIC recognizes that all forms of literacy are fundamentally intertwined. In addition, skill and confidence in one form of literacy will inevitably impact skill and confidence in other forms of literacy. The terms numeracy, quantitative literacy, and quantitative reasoning are used throughout the literature, sometimes interchangeably, sometimes with subtle differences. The QL-CIC prefers the term "Quantitative Reasoning" to encompass our efforts and objectives at Curry. We feel that "Reasoning" suggests a greater depth of engagement and avoids confusion with other forms of literacy. To that end we have developed the following definition of Quantitative Reasoning.

Quantitative Reasoning
is a habit of mind that effectively
understands,
investigates,
communicates,
and contextualizes
numerical and graphical information
in the evaluation and construction of arguments.

With this understanding of QR, we produce the following learning objectives. A student meeting a quantitative reasoning requirement should be able to: .

1. Discuss quantitative results (e.g. how precise, how reasonable, how typical, how useful) in context of both the problem and general, real-world knowledge.

2. Interpret multiple representations of quantitative information and draw inferences from them. Representations of quantitative information can be symbolic (e.g., a formula or symbolic language), visual (e.g., a graph, diagram or schematic), numerical (e.g., a table of values or calculation), or verbal (e.g., written or oral work).

3. Communicate quantitative information effectively incorporating symbolic, numeric, and/or graphical representations within verbal communication.

4. Assess problems quantitatively by identifying relevant quantitative evidence, stating issues in numerical terms, and selecting appropriate quantitative methods.

5. Solve problems and make decisions using multiple quantitative methods. Quantitative methods of problem solving include any of those among arithmetic, algebraic, geometric, algorithmic, and statistical methods.

6. Analyze solutions to quantitative problems. Methods of analysis may include plausible estimation, testing for reasonableness, verifying the solution by using alternate methods of problem solving, and testing the solution to see if it is optimal.

7. Demonstrate recognition of the value and the limitations of quantitative methods.

Our learning objectives were originally developed at the request of Gen Ed. The initial bases for our Quantitative Reasoning objectives are the recommendations provided by the Mathematical Association of America and the American Association of Colleges and Universities, as implemented by Simpson's College. We modified these initial objectives as follows:

- Requiring student familiarity with multiple forms of quantitative methods and representations, instead of one of many. This is because these objectives are at the institutional, rather than course, level. Some QR courses may focus on one approach, but throughout their experience at Curry, we want students to be familiar with multiple approaches.

- Added a "discuss" objective to emphasize that students need to be able to discuss quantitative results in context, as separate from applications of quantitative methods. For instance, using demographic numbers in context to frame arguments in papers.

- Added an "evaluate" objective to focus on how students begin problems solving in a quantitative context.

QR & Gen Ed

Prior to the existence of the QL-CIC, the Gen Ed Committee had discussed a quantitative reasoning component. In addition, one member of the CIC is also on Gen Ed, which allows for some cross pollination of ideas. Early in the fall semester, Gen Ed requested a set of learning outcomes for a Quantitative Reasoning requirement. The group provided the outcomes above, along with a rationale. When Gen Ed showed its model to the college, the group had a few concerns regarding the quantitative reasoning component. The main concern was the lack of QR throughout the curriculum, as we would prefer a more embedded instruction. We also wanted to ensure that Gen Ed understood the difference between Quantitative Reasoning and Mathematics, and that replacing a mathematics requirement with QR results in a decrease in the amount of mathematics content required. (See Appendix for formal communications with Gen Ed.)

Placement & Assessment

In order to teach students effectively, it is important to have a good sense of their mathematical and quantitative understanding. The group spent some time discussing assessment and placement as presently implemented at Curry. Our discussions were informed by the current placement practices, examining the current placement exam, looking past Curry placement scores under other exams, and reading the mathematics area's placement proposal. (See Appendix for proposal.)

The unanimous consensus was that the current placement test is ineffectual and a valid, reliable test with standardized administration procedures is needed. We believe that the math area's proposal will address these needs. Specifically, we recommend:

- The current placement test should be replaced with a reliable and valid diagnostic tool, preferably one that is already widely used.
- Placement testing should be done in a proctored, controlled environment on campus, preferably with as much automation as possible. (See Quantitative Commons.)
- A staff position should be created to oversee the set-up, scheduling, and administration of the test and to coordinate with departments and advisors on using the test results. (See Quantitative Commons)
- The test should provide diagnostic scores by content or skill area, not just one overall score.
- Departments should use test subscores as prerequisites for their courses, to both emphasize and apply a stricter standard on the quantitative levels needed for course success.

Survey Results

The QR committee sought information about faculty knowledge, attitudes and concerns about the integration of QR content across the curriculum. To this end, the QR committee designed and deployed a survey questionnaire.

Questions were designed to elicit information about the extent to which QR is embedded in current teaching (i.e. frequency with which QR concepts are taught) as well as specific approaches used (e.g. scaling, orders of magnitude). Additional questions attempted to elicit information about concerns or barriers to incorporation of QR concepts (Appendix A).
All full and part time faculty (N= 495) were emailed a link to the Quantitative Reasoning Survey, which was conducted using an online survey tool (Survey Monkey). Fifty-four respondents provided feedback.

Frequency: *How often do you incorporate quantitative reasoning into your teaching?*
24% of respondents reported that they never or seldom incorporated QR
33.3 % of respondents reported that they occasionally incorporated QR
42.6% of respondents reported that they frequently or always incorporated QR

Types of QR that are taught: *Which of the following do you use in your teaching?*
Respondents were most likely to use percentages/ratios (87.5%), demographics (72.9%), numerical comparisons between groups (60.4%), frequency (54.2%), correlations (50%), graphical displays such as charts and bar graphs (50%), rates and changes in quantities (47.9%).

Respondents were less likely to use scaling/measuring (39.6%), pattern recognition (29.2%), conversions (22.9%), and orders of magnitude (20.8%).

Relevance: *How relevant do you believe that QR is to success in your area?*
62.9% of respondents felt that QR skills were important for success in their (the faculty members) respective fields
18.5%felt that QR skills were somewhat important
18.5 % felt that QR skills did not have great relevance for success in the field

Concerns: *What concerns do you have about incorporating QR into your class?*
37.3% had no concerns regarding integrating QR
The largest aspect of concern was student barriers to adopting QR: Concerns about student ability (35.3%), student belief in relevance (29.4%), and student anxiety 25.5%.
A relatively small number of the faculty were concerned about their own issues regarding QR: Class time (21.6%), expertise (17.6%), relevance (13.7%), and workload (11.8%).

Interest in learning more about integrating QR into teaching:
42.8% of faculty were extremely or very interested in learning more about QR
26.5% of faculty were somewhat interested in learning more about QR
30.6% of faculty had little/no interest in learning more about QR

Best approaches to learning (for faculty):
Faculty who were interested in learning more about QR felt that these approaches would be helpful:
63.6% Informal small presentations (N=28)
36.4% Excellence in Teaching workshops (N=16)
36.4% Faculty retreat (N=16)

Faculty was less interested in:
29.5% Online information (N=12)
27.3% Summer Institute (N=13)

Little interest was found for individual approaches:
13.6% Personal mentoring (N=6)
13.6% Peer support (N=6)

Based on the survey results, we recommend that the Faculty Center hold Faculty Swim sessions on incorporating quantitative reasoning into course content.

Quantitative Commons

Recommendation: The QL CIC recommends that the College develop a Quantitative Commons. This is both a concept and a carefully designed physical space. The creation of this space is critical to the ongoing development of quantitative literacy across the College. We recommend that the dean appoint a task force to implement the Quantitative Commons.

Rationale: Quantitative literacy figures prominently in the College's liberal arts core curriculum and is a central element of the college's mission statement. Capstone courses are central to most of the college's majors, and the college seeks to bolster research training and research as a centerpiece of these courses. Numerical and quantitative literacy are key educational elements for all of the college's students, as well as its science majors.

The College's most populated programs are professional or pre-professional: nursing, psychology, education, criminal justice and management, all of which depend significantly upon quantitative reasoning. Increased testing and tutorial support has strengthened the institution's entry-level mathematics requirements and continued work is planned for the future. Of great interest in the near future is the further development of STEM competencies, particularly in intermediate and upper level curricula that depend upon quantitative reasoning, including applied mathematics, genomics, statistics and capstone courses in the social sciences and sciences. Capstone courses are central to Curry's majors and the institution seeks to bolster undergraduate research as a centerpiece of these courses. With additional support for infrastructure, Curry will be well-positioned to model an integrated quantitative reasoning program with the academic supports necessary to meet the quantitative needs of the 21st century workforce. Such efforts will combine the high quality instructional practices that have been part of Curry's long-standing traditions in focusing on the individual learner with best practices in instructional design and the physical resources necessary for promoting engaged student learning.

The Quantitative Commons is conceived as a shared facility with specific physical and cyber-infrastructure to enhance and encourage education and research training across the curriculum, using best practices in contemporary pedagogy. Specifically, the Commons is intended to:

- Improve student learning in quantitative reasoning
- Facilitate student training in research
- Facilitate faculty research of all kinds, including research on teaching and learning
- Enhance the visibility of quantitative reasoning in the broad college community
- Provide space and facilities to examine, experiment with, and assess quantitative technology tools

- Provide multiple forms of instruction including professional tutors, peer tutors, self-study materials, and on-line materials
- Function as a site for administration of placement testing in mathematics, and other disciplines, as appropriate
- Foster undergraduate research experience, including capstone projects
- Enhance recruitment of science majors to the college

Broader impacts include contributions to the education of a quantitatively literate citizenry, preparation for employment in the 21st century workforce, preparation for graduate and professional education in quantitative fields, including and beyond STEM, and entrainment of the college's learning disabled students into mainstream quantitative pedagogy.

Purpose: Following best practices in learning theory, mathematics education and learning space design, we envision a quantitative commons that will:

- Improve student learning in quantitative reasoning
- Facilitate undergraduate research and faculty research
- Make quantitative reasoning visible to the broader college community
- Offer space and facilities to examine, experiment and assess quantitative IT tools
- Integrate with a dedicated placement testing facility
- Be distinct from AEC in that it is not remedial; will coordinate with AEC

The space: Dedicated space is central to this enterprise. Desired physical characteristics of the Commons include:

- Classroom space as an agent to increase group learning, work, time on task, and making questions and answers visible to facilitate new patterns in student behavior, student-faculty interactions and faculty-faculty interactions
- Dedicated areas (with materials) that target specific topics and needs including unit conversions, placement preparation, display of quantitative information (tables and graphs), reading and writing of quantitative information, statistics, and research methods
- Flexible working spaces allowing students and faculty to interact informally, with quantitative reasoning as a shared aim for all

- Table space for sharing and using different tools
- Integrated technology throughout the learning spaces (workstations, wired and wireless, tablets, server support, raised flooring, etc.)
- Shared screens for group facilitation, including whiteboards and Smartboards
- Flexible, modular furniture with an emphasis on small group work
- Full array of relevant software packages
- Flexible spaces for individual and group study that support a learning culture
- Classrooms to be used for all mathematics courses and quantitative courses offered by other departments, and kept open for flexible learning and research at other times
- Ideally, be grouped with other student support services (AEC, Writing Center) under the umbrella of an overall "Learning Commons"
- A placement/assessment testing facility for department specific quantitative assessment needs (such as nursing math competency test or other areas).

This shared learning space should be based on successful models for innovative teaching and learning spaces at other institutions, including:

- Stanford University (http://www.educause.edu/learningspacesch35),
- Virginia Polytechnic Institute (http://www.educause.edu/learningspacesch42),
- North Carolina State University (http://www.educause.edu/learningspacesch29).

LaGuardia Community College and Bunker Hill Community College have Quantitative Commons that might serve as models. Courses taught in the space would include applied mathematics, upper level mathematics, statistics and genomics. In addition, the offices of full-time faculty with expertise in applied mathematics and statistics would be located in proximity to the Quantitative Commons so that they could be available for assistance with students and other faculty.

Services: All mathematics classes, and quantitative courses offered by other departments, would be taught in dedicated Quantitative Commons' classrooms. Staffing hours would focus on student needs, with attention to, Continuing Education students and graduate students, whose time needs center on ca. 1.30 pm-midnight.

The Quantitative Commons would offer a broad menu of services including:

- Placement testing
- Preparation for placement testing
- Targeted support for areas of placement testing weakness
- Workshops
- Seminars/lectures focused on inspiring QR-based study, e.g., why evidence-based practice matters
- Tutoring for classes
- Assistance with forming and maintaining study groups
- Boot camps--summer, winter break or spring break intensive study experiences
- MTEL preparation
- Nursing math testing for clinical rotations
- Internship opportunities for Education majors
- Non-credit introductory quantitative skills courses
- Support for SoTL efforts led by the College's Faculty Center for Professional Development and Curriculum Innovation

Staffing: Mathematics faculty offices would be located in the Commons. The Commons would be staffed by a full-time Coordinator, whose duties would include oversight of the center's physical and technological facilities, coordination of center activities, liaison with other components of the broader "Learning Commons" (Writing Center, AEC, and Library), coordination of tutoring activities, and oversight of placement exams. Tutoring staff would include professional tutors and peer tutors.

Potential Issues and Other Factors: A number of issues have been identified that would need to be addressed during the formation of the Quantitative Commons.

- Resources should be well articulated.
- Faculty need to work with the Commons, providing information about courses, textbooks, supplemental course materials, prototype exams, etc.

- The Commons should have expected outcomes that should be articulated.
- There is not presently a high demand from students for QR services (in contrast to Writing and English), so services need to be publicized and "sold".
- Need to connect the Commons to real life experiences.
- Access to Commons services for students from the satellite campus in Plymouth.
- The current student culture prefers individual tutoring to peer tutoring--how to overcome this?
- Support of faculty in learning new pedagogy should be done through the Faculty Center and coordinated with the Quantitative Commons.
- Need to define mechanisms of support in quantitative literacy for the College's learning disabled students, in collaboration with PAL faculty.
- Mechanism for paying professional tutors needs to be defined within the scope of the CBA, if tutors are faculty or part-time faculty.
- Funding to pay peer-tutors needs to be allocated.

QR & PAL

At our meeting on February 21st, the quantitative literacy CIC met with Joe Cullen from PAL (Program for the Advancement of Learning) to discuss quantitative related learning disabilities. He spoke with us about dyscalculia and PAL. (Please see the handout he provided, which nicely summarizes dyscalculia in general and with regard to PAL students.)

Dyscalculia is defined as an extreme difficulty in understanding quantitative information. This difficulty exists regardless of IQ, home environment or learning opportunities. However, there are several teaching methods that work well in overcoming dyscalculia. They include (from handout): embedding quantitative content in a practical/meaningful context, providing extra time and repetition, eliminating the anxiety around math, using assistive technologies, and utilizing metacognitive strategies.

The QL CIC group discussed quantitative reasoning with Joe Cullen in general, at PAL, and at Curry. The highlights of our discussion include:

- PAL has formed a “Math committee” to investigate how to better support students with math based LD
- PAL has ceased to prioritize verbal learning disabilities over math and expects to see more students with math based learning disabilities (but stronger overall profiles).
- PAL hopes to have a summer summit in the next year or two to work with various groups in the college regarding helping students with math learning disabilities.
- In the past, PAL advisors have often recommended that students wait to take their math course until after their freshman year, believing that because these students have difficulty in math, they need to see success in college first before attempting to complete their math requirement(s). In addition, working with these students in quantitative classes is a significant challenge for PAL professors. This is a point that Joe is working to change.
- “Math” works best for students with learning disabilities when it is directly connected to their lives and they can see its value. Math that is “hands-on” is also helpful.
- We need to change student mindset about math first. Ill-conceived perceptions about math are significant learning blocks to quantitative reasoning.
- We want to make QL an agenda for both Curry and PAL

We also discussed with Joe Cullen the need to frame this as quantitative reasoning instead of just math as a way to shift the thinking about it.

Campus Curriculum and Culture Recommendations

In order to improve quantitative reasoning at Curry, we believe there needs to be a cultural change as well as a curriculum shift. Students are weak in QR and resistant to developing those skills. Creating a culture of expectation and exposure to quantitative based thought processes is a way to begin addressing these issues.

Goal: To raise awareness and use of Quantitative Reasoning outside the classroom.
Suggestions:

- Invite and encourage people making posters and bulletin boards on campus to use more quantitative content. Residence Life and Social Justice classes have been using numbers to frame their points. We think that is great and would like to see more *numbers in context* being used. The context part is an important piece of QR -- not just how many, but drawing comparisons. Example: there are XXX beds on campus for YYYY students.

- Request that *Curry Times* and other publications include more quantitative reasoning based components, such as charts, graphs, Sudoku, kenken, etc. (According to Jeff Lemberg Sudoku costs quite a bit for papers to run.) Consider running more statistics for Boston and Curry sports teams and having students use QR to evaluate performance.

- Add links to quantitative reasoning based games to the Curry portal.

- Ask Career Services to emphasize the role that QR plays in getting and succeeding in jobs.

- Emphasize a QR component in Library displays.

Goal: To increase faculty awareness, comfort level, and appreciation for QR
Suggestions:

- Recruit more QR-centered people to committees (ex. Excellence in Teaching, UCC). Talk with people currently on committees about the importance and relevance of QR.

- Recommend that Excellence in Teaching host events with strong QR aspects

- Over the longer term, plan a Summer Institute for faculty on QR. We believe that the current faculty awareness and interest level is not high enough to make this a viable short term recommendation.

- Encourage , promote, and provide logistical support for faculty arranging talks (internal or with outside speakers) that highlight quantitative approaches.

Goal: To promote and increase the teaching of QR in courses
Suggestions:

- Faculty Quantitative Awards – Awards from the Faculty Center (or Excellence in Teaching) presented to instructors for excellent use of quantitative reasoning in a course. There should be awards both for strengthening of QR (in quantitative heavy disciplines) and for innovating with QR (bringing QR into a course that haven't had any). Award winning courses and instructors should be advertised (e.g., Curry Times, Digital Boards, Radio, Advising bulletin board, etc.) so that students are aware of it.

- Call for Quantitative Enriched courses. We recommend that the Faculty Center put out a call for experimental Quantitative Enriched course. These would be courses that are not quantitatively heavy by nature, but could be enriched by a quantitative component. The Faculty Center would support faculty who apply to enrich their courses. Recommended types of support include:
    - Cap on class size
    - Mentoring by quantitatively based faculty
    - Guidance and resources from quant faculty or Faculty Center on ways to enrich the course
    - Certificates for DEC files and public acknowledgement
    - Promotion (advertisement) of course to students and advisors
- Faculty swim sessions on incorporation of QR into courses
- Student Quantitative Awards – Student Services or Dean's Office would issue an award for quantitative work by a student at Awards Night. This would be a non-discipline specific award. This is a long-term recommendation that could be considered after student portfolios are in place.
- Long-term increased support or focus on Quantitative Enriched (QE) courses, both on strengthening existing QR type courses and innovating other course with QR components. Ideally this would be part of a campus wide movement similar to Writing Across the Curriculum.

Learning repository

We recommend that the college investigate the viability of a learning repository that would make available a variety of learning activities (often called learning objects) to Curry faculty. Learning objects have been defined as instructional content, multimedia content, learning objectives, instructional software and tools.

The repository would be useful not only for quantitative reasoning, but all disciplines. Along with investigating the viability of a repository, the location question will need to be answered. Repositories need to be searchable, accessible, and integrated into the teaching process. Often they are integrated into an institution's LMS.

The QR CIC has gathered some notable national sites on its Blackboard site, but why might a local learning repository be useful?

It will allow for local **sharing and reusing** of learning objects. The QR survey indicated that a number of faculty are willing and interested in incorporating QR concepts into their courses, but are not sure how to approach it, have concerns about additional faculty workload, and are skeptical about student capacity in this area. The QR CIC brainstormed some ways faculty support and learning could occur in this area, as well as asking faculty in the survey. Nearly 30% of the respondents indicated an interest in online learning. A repository could help in this work.

Thus, a repository can be **discipline neutral**. Examples of successful tutorials, assessments and projects can be made available with the possibility of revising them for a specific discipline, thus optimizing development time.

Localization: The learning repository can highlight activities that were successful for Curry students and emphasize broad Curry learning outcomes. Their interactive nature (ideally) makes them useful for both traditional and online or hybrid courses.
An investigation would help to define the pedagogical needs and technical challenges such an initiative would encounter and if a local initiative would be have benefit to Curry College faculty and students.

We recommend that Ed Tech pursue this initiative.

QR and Writing

There are important connections between QR and writing, and these provide strong justification for integrating QR into writing assignments and writing courses. Writing is both a tool for, and an expression of, the organization and evaluation of ideas. Quantitative concepts and data are integral to a broad diversity of content areas, from the social and natural sciences to politics and public policy, to management of one's own daily affairs. Consequently, QR "habits of mind" are a *sine qua non* of meaningful organization and evaluation of ideas in these content areas.

Carleton College provides an example of the integration of QR with writing programs. In discussing the motivation for the Carleton program, Grawe and Rutz http://serc.carleton.edu/files/quirk/ProgramDesign/grawe_rutz_paper.v3.pdf speak of the need to foster "the habit of mind to consider the power and limitations of quantitative evidence in the evaluation and construction of arguments in personal, professional, and public life... Simply put," they state, "we seek to harness the rhetorical power of numbers."

We believe that for QR to be an effective part of the curriculum, it must be integrated and cannot be a one-shot exposure that students just "get through." Just as the development of reading and writing skills should not be considered completed at the end of high school, but are expected to continue to develop at progressively more sophisticated levels throughout college (and beyond), QR skills should likewise be expected to broaden and deepen throughout a college education. And just as language skills such as grammar and punctuation are best developed not by instruction focusing on rules but by continued exposure and contextualized practice, the manipulative skills of

mathematics are best developed by being repeatedly revisited in contexts that are of evident relevance to the student.

Although the reasons for integrating QR into writing are clear, how best to do it is more problematic. People teaching writing courses or giving writing assignments may need support to various degrees, or may need to be persuaded of the value of integrating QR. In some cases, faculty are already integrating QR to various degrees without fully realizing that they are doing so, and there the need is to get them to be more intentional about how they are using QR, and to make its importance explicit to their students.

To consider what more might be done, and also to understand better what some of the obstacles are, the QL CIC met with some members of the WAC CIC to discuss QR and writing. Suggestions for incorporating QR more fully into written work included:

- Making it matter to students (tying QR to *their* real world)
- Including QR approaches in the learning outcomes for writing (One good list of goals and outcomes appears as Table I in the Grawe and Rutz article.)
- Providing suggestions to the writing faculty for mini objectives for involving QR in writing
- Providing a short handout/rubric/guide to the writing faculty on assessing QR in writing
- Providing information on assessing QR in writing to the 2012-1013 CIC focused on e-portfolios, so that they are aware of this issue
- Targeting writing for mini workshops to raise awareness of how QR may already be involved in some of their writing assignments, and to provide examples of other possibilities for its involvement
- Using service learning courses, if they are created, as a good opportunity for contextualizing this integration

The meeting also took note of student weaknesses that are potential obstacles:

- Many of our students have poor reading comprehension. This is an obstacle to their dealing with organization and evaluation of information in general, as well as with content of a quantitative nature. Difficulty with the latter may be more pronounced.
- Some students use numerical information rather randomly in their writing (e.g. being inattentive to the number of zeroes in a copied number or in a numerical word such as “million”)
- Too many students are credulous about information given in numerical form (e.g. “It’s objective fact because they’re providing numbers.”)

There was a shared conviction among those attending the meeting that integrating QR into writing is an important goal, and shared recognition of the need to bring on board those faculty who are less

convinced of the value of doing so, or less sure of what they can do about it in their own courses and assignments.

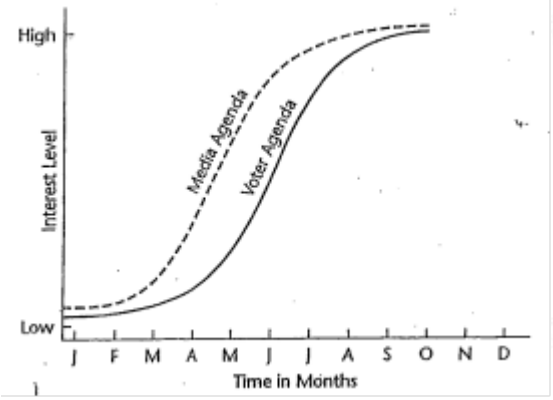
Based on our readings and Carleton College's QUIRK resources, we developed a basic rubric for evaluating quantitative reasoning in non-technical papers, along with a basic handout for students to use in thinking about quantitative reasoning in their papers. Additionally, we adopted some very basic goals and objectives for quantitative writing. These resources were shared with the Writing Faculty, the Capstone Assessment group, the Learning Outcomes Assessment Committee, and those exploring e-portfolios. See Appendix for copies.

Teaching Tips and Examples

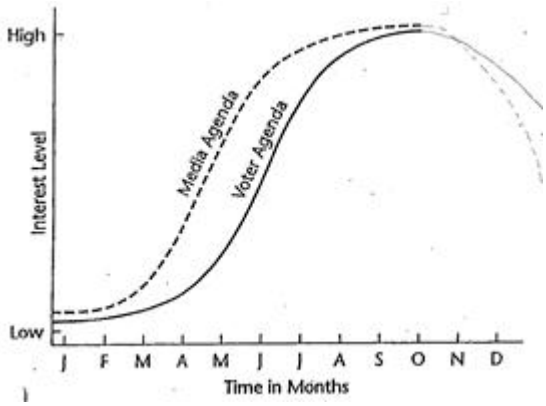
At the December CIC gathering, we presented some basic ideas for how to embed quantitative reasoning into courses. This document, Embedding QR, is in the appendix. QL CIC member Rob MacDougall also met with faculty to discuss how they are using quantitative reasoning in the classroom. Here are some selected examples:

1. Basic math course assignment (Wang): two Macy's coupons for a pair of jeans (25% and $10 off). Which is a better deal?

2. Communication Theory (MacDougall) Demonstrating difference between correlation and causation via x/y axis curves showing relationship between media agenda and voter agenda (interest level/issue salience) over time.:



(Only correlation can be claimed here)



(We begin to see a suggestion for a causal relation here)

3. Other: you have $3.000 for a 5-day European trip – how to spend it best: %s, discounts, comparing, etc. (Students love to spend money, so this is an easy sell). This taps into technological, information, media, and cultural literacy.

Key Points from Readings

The group read articles on a variety of aspects of quantitative reasoning, from assessment, to writing, to national standards. Many of our readings came from one of two books, *Current Practices in Quantitative Literacy* and *Why Numbers Count*. Each member received a copy of one of these two books to keep. We also made use of the on-line book, *Calculation versus Context*. A complete list of the articles read is listed in Appendix: Reading List. Some members also read parts of *Math for Life*, a quantitative book targeted at popular audiences. We highly recommend *Math for Life* is to those in non-quantitative disciplines who want to have a greater understanding of quantitative reasoning and its relevance in everyday life. We also recommend the article *Arguing with Numbers*, which addresses both the why and how of teaching of quantitative reasoning in context, based on Carleton College's QUIRK program.

Some key ideas we discussed from these readings:

- How Quantitative Reasoning differs from Mathematics
- Quantitative Reasoning is a vital life skill
- Quantitative Reasoning courses are worthy of college credit
- Context is important for teaching Quantitative Reasoning
- Quantitative Reasoning is used in a wide variety of areas
- Communication is an integral skill in developing Quantitative Reasoning
- Quantitative Reasoning is best taught integrated with content
- Assessing Quantitative Reasoning skills can be challenging and involve substantial efforts

Appendices

Appendix - Learning Repository

http://www.ciese.org/pathways/rwlo/search.php

The Real World Learning Objects (RWLO) Resource Library is an online repository of Internet-based unique and compelling learning objects designed so that community college faculty can easily access and adapt for use in their classes.

http://www.merlot.org/merlot/index.htm
MERLOT is a free and open online community of resources designed primarily for faculty, staff and students of higher education from around the world to share their learning materials and pedagogy. MERLOT is a leading edge, user-centered, collection of peer reviewed higher education, online learning materials, catalogued by registered members and a set of faculty development support services.
MERLOT's strategic goal is to improve the effectiveness of teaching and learning by increasing the quantity and quality of peer reviewed online learning materials that can be easily incorporated into faculty designed courses.
http://www.ariadne-eu.org/

The **ARIADNE Foundation** is a not-for-profit association that aims to foster *Share and Reuse of Learning Resources*. Facilitating the reuse of *digital resources that can be used to support learning* (i.e. educational content or learning objects has been its goal for several decades.

http://www.smete.org/smete/

The SMETE Open Federation was formed to promote the teaching and learning of science, mathematics, engineering and technology at all levels. The Federation was built with funding by the National Science Foundation, National STEM Education Digital Library program and partnerships with nationally recognized professional educational organizations, academic institutions and private e-learning companies. The SMETE Open Federation community fosters the ongoing collaborative development among partner organizations, provides tools and services to support collection and service providers, and ensures stability, sustainability and scalability of the Federation's programs and projects.

http://www.mcli.dist.maricopa.edu/mlx/

Their website states: Welcome to the Maricopa Learning eXchange (MLX), which at current inventory status includes **1819** "packages" in our warehouse of learning. As our "X" shows, our address is at the intersection of *Teaching* and *Learning.*

http://www.jorum.ac.uk/

Jorum is a JISC-funded Service in Development in UK Further and Higher Education, to collect and share learning and teaching materials, allowing their reuse and repurposing. This free online repository service forms a key part of the JISC Information Environment, and is intended to become part of the wider landscape of repositories being developed institutionally, locally, regionally or across subject areas. We use a modified version of DSpace for Jorum.

www.iTunesU.com

iTunes U brings the power of the iTunes Store to education, making it simple to distribute information to your students and faculty — or to lifelong learners all over the world. With an iTunes U site, your institution has a single home for all the digital content created or curated by educators, which can then be easily downloaded and viewed on any Mac, PC, iPod, or iPhone.

http://www.thirteen.org/get-the-math/

GET THE MATH is a convergent media project designed to help middle and high school students develop algebraic thinking skills for solving real world problems. Drawing on conventions of popular reality TV shows, video segments begin with profiles of young professionals, who then pose challenges connected to their jobs to two teams of teens. At that point viewers are encouraged to try the challenges themselves using interactive tools provided on the *GET THE MATH* website, before returning to the video to see the teams' solutions. Students can further explore the same algebra concepts through additional interactive challenges on the website.

http://www.nsdl.org/

NSDL is the nation's online portal for education and research on learning in Science, Technology, Engineering, and Mathematics.

http://teachingwithdata.org/qssdl/welcome.action

TeachingWithData.org is portal of teaching and learning resources for infusing quantitative literacy into the social science curriculum. A Pathway of the National Science Digital Library, TwD aims to support the social science instructor at secondary and post-secondary schools by presenting user-friendly, data-driven student exercises, pedagogical literature, and much more! Resources are available on a wide range of topics and disciplines.

http://www.icpsr.umich.edu/icpsrweb/OLC/

ICPSR's Online Learning Center (OLC) supports quantitative literacy in the social sciences by providing an effective and reliable means of bringing secondary data into the classroom. Teaching faculty designed, built, and tested OLC tools. OLC tools and resources assist faculty who strive to help students open the door to the world of statistical literacy and substantive inquiry. Use of the Data-Driven Learning Guides builds numeracy and fosters excitement through exploration of concepts as they apply to the real world.

http://www.ssdan.net/

The Social Science Data Analysis Network (SSDAN) is a university-based organization that creates demographic media, such as user guides, web sites, and hands-on classroom computer materials that make U.S. census data accessible to policymakers, educators, the media, and informed citizens. SSDAN is directed by demographer William H. Frey and utilizes facilities at the Population Studies Center, University of Michigan. SSDAN activities have been supported by the National Science Foundation, the Annie E. Casey Foundation, the U.S. Department of Education Fund for the Improvement of Post-Secondary Education (FIPSE), the National Institute of Child Health and Human Development (NICHD), the Alfred P. Sloan Foundation, Public Data Queries, Inc., and the U.S. Census Bureau.

http://www.terc.edu/

For more than forty years, TERC has been introducing millions of students throughout the United States to the exciting and rewarding worlds of math and science learning. Led by a group of experienced, forward-thinking math and science professionals, TERC is an independent, research-based organization dedicated to engaging and inspiring all students through stimulating curricula and programs designed to develop the knowledge and skills they need to ask questions, solve problems, and expand their opportunities.

Assignments, Activities, Examples, etc.

1.)
Ideas from the English department at Highline Community College:
http://flightline.highline.edu/english/ideas/ql.php

2.)
A Statistical Analysis of Editorial Influence and Author–Character Similarities in 1990s New Yorker Fiction
Literary and Linguist Computing *(2007) 22 (3): 305-328.*
We present a quantitative analysis of 442 pieces of fiction published between 5 October 1992 and 17 September 2001 in the *New Yorker* magazine. We address two independent questions using the same data set. First, we examine whether changes in the Executive Editor or Fiction Editor are associated with significant changes in the type of fiction published at the *New Yorker*. Second, we examine whether *New Yorker* authors write fiction more often than not about characters with whom they share demographic traits. We find that changes in Fiction Editor at the *New Yorker* are associated with numerous significant, quantifiable changes in the magazine's fiction and that these effects are greater than those associated with a change in the *New Yorker*'s Executive Editor. We also find that authors of *New Yorker* fiction write significantly more often than not about protagonists who share their race, gender, and country of origin and who are within or below their age range. The same is true of secondary characters except in the case of gender.

3.) Carleton College's Quirk Initiative: http://serc.carleton.edu/quirk/index.html "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." The site has resources for courses, assessment, and research information.

4.)LaGuardia Community College's collection of math skills links, targeted towards the social sciences. http://www.lagcc.cuny.edu/socialscience/economics/mathskillshelp.html

Appendix: Reading List

Bennett, Jeffrey, *Math for Life: Crucial Ideas You Didn't Learn in School,* (Roberts and Company Publishers, 2011).

Comex, Dogan and William O. Martin, "Quantitative Literacy as an Integral Component of Mathematics Curriculum", in *Current Practices in Quantitative Literacy*, ed. Rick Gillman, (Mathematical Association of America, 2006), 155-164.

Dossey, John A. "National Indicators of Quantitative Literacy", in *Why Numbers Count: Quantitative Literacy for Tomorrow's America* ed. Lynn Arthur Steen, (College Board, 1997), 45-59.

Dossey, John A. "Appendix: Defining and Measuring Quantitative Literacy", in *Why Numbers Count: Quantitative Literacy for Tomorrow's America* ed. Lynn Arthur Steen, (College Board, 1997), 173-186.

Ganter, Susan L. "Issues, Policies, and Activities in the Movement", in *Current Practices in Quantitative Literacy*, ed. Rick Gillman, (Mathematical Association of America, 2006), 11-16

Gillman, Rick, "A Case Study of Assessment Practices in Quantitative Literacy", in *Current Practices in Quantitative Literacy*, ed. Rick Gillman, (Mathematical Association of America, 2006), 165-170.

Grawe, Nathan D. and Carol A. Rutz, "Integration with Writing Programs: A Strategy for Quantitative Reasoning Program Development" *Numeracy* Manuscript 1036..

Lutsky, Neil, "Arguing with Numbers: Teaching Quantitative Reasoning through Argument and Writing", in *Calculation versus Context* ed. Bernard L. Madison and Lynn Arthur Steen,(Mathematical Association of America, 2008), 59-74.

Mast, Maura and Mark Pawlak, " Quantitative Reasoning at the University of Massachusetts Boston", in *Current Practices in Quantitative Literacy*, ed. Rick Gillman, (Mathematical Association of America, 2006), 87-94.

Pollak, Henry, O. "Solving Problems in the Real World", in *Why Numbers Count: Quantitative Literacy for Tomorrow's America* ed. Lynn Arthur Steen, (College Board, 1997), 91-104.

Shavelson, Richard J, "Reflections on Quantitative Literacy: An Assessment Perspective", in *Calculation versus Context* ed. Bernard L. Madison and Lynn Arthur Steen,(Mathematical Association of America, 2008), 27-44.

Steele, Benjamin and Smra Kilic-Bahi, "Quantitative Literacy Across the Curriculum", *Numeracy* Volume 1, Issue 2 (2008): Article 3.

Appendix: QR Definition and Learning Outcomes

A student meeting a QR requirement should be able to:

1. Discuss quantitative results (e.g. how precise, how reasonable, how typical, how useful) in context of both the problem and general, real-world knowledge

2. Interpret multiple representations of quantitative information and draw inferences from them. Representations of quantitative information can be symbolic (e.g., a formula or symbolic language), visual (e.g., a graph, diagram or schematic), numerical (e.g., a table of values or calculation), or verbal (e.g., written or oral work)

3. Communicate quantitative information effectively incorporating symbolic, numeric, and/or graphical representations within verbal communication

4. Assess problems quantitatively by identifying relevant quantitative evidence, stating issues in numerical terms, and selecting appropriate quantitative methods

5. Solve problems and make decisions using multiple quantitative methods. Quantitative methods of problem solving include any of those among arithmetic, algebraic, geometric, algorithmic, and statistical methods

6. Analyze solutions to quantitative problems. Methods of analysis may include plausible estimation, testing for reasonableness, verifying the solution by using alternate methods of problem solving, and testing the solution to see if it is optimal

7. Demonstrate recognition of the value and the limitations of quantitative methods

Appendix: Communications with Gen Ed

Initial report to Gen Ed on 10/17/2011:

Quantitative Literacy (Numeracy) and consequently Quantitative Reasoning, are vital competencies for success in school, career, and functioning in society. The QL-CIC recognizes that all forms of literacy are fundamentally intertwined. In addition, skill and confidence in one form of literacy will inevitably impact skill and confidence in other forms of literacy. We believe QL can be taught in some form across the curriculum; current efforts may need to be articulated or emphasized.

The initial basis for our Quantitative Reasoning objectives is the recommendations provided by the Mathematical Association of America and the American Association of Colleges and Universities, as implemented by Simpson's College. We modified these initial objectives as follows:

- Requiring student familiarity with multiple forms of quantitative methods and representations, instead of one of many. This is because these objectives are at the institutional, not course, level. Some QR course may focus on one approach, but throughout their experience at Curry, we want students to be familiar with multiple approaches.

- Added a "discuss" objective to emphasize that students need to be able to discuss quantitative results in context, as separate from applications of quantitative methods. For instance, using demographic numbers in context to frame arguments in papers.

- Added an "evaluate" objective to focus on how students begin problems solving in a quantitative context.

A student meeting a QL/QR requirement should be able to:

1. discuss quantitative results (e.g. how precise, how reasonable, how typical, how useful) in context of both the problem and general, real-world knowledge

2. interpret multiple representations of quantitative information and draw inferences from them. Representations of quantitative information can be symbolic (e.g., a formula or symbolic language), visual (e.g., a graph, diagram or schematic), numerical (e.g., a table of values or calculation), or verbal (e.g., written or oral work)

3. communicate quantitative information effectively incorporating symbolic, numeric, and/or graphical representations within verbal communication

4. evaluate problems quantitatively by identifying relevant quantitative evidence, stating issues in numerical terms, and selecting appropriate quantitative methods

5. solve problems and make decisions using multiple quantitative methods. Quantitative methods of problem solving include any of those among arithmetic, algebraic, geometric, algorithmic, and statistical methods

6. analyze solutions to quantitative problems. Methods of analysis may include plausible estimation, testing for reasonableness, verifying the solution by using alternate methods of problem solving, and testing the solution to see if it is optimal

7. demonstrate recognition of the value and the limitations of quantitative methods

QL CIC's response to the Gen Ed proposal, sent 11/28/2011

QL-CIC Response to the Quantitative Reasoning component of the Gen Ed Proposal
The group has two main concerns regarding the how quantitative reasoning (QR) is handled in the current Gen Ed proposal: the combining of QR and math, and the limiting of QR to a first year course and the sciences.

- **QR/Math First Year Course**

Although basic mathematical skills are needed for in-depth quantitative reasoning, the topics are different. We are concerned that a math/QR requirement may short change both. We believe that QR is a vital life skill for students in general, but that a liberal arts college graduate should have math skills as well. In *Reflections on Quantitative Reasoning* by Shavelson, there is a table illustrating one view of differences between mathematics and QR, which we've included below. We want to make sure that GenEd is aware that these areas are different, though they do interact and overlap, so that GenEd curriculum takes this into account.

Mathematics	Quantitative Reasoning
Power in abstraction	Real, authentic contexts
Power in generality	Specific, particular applications
Some context dependency	Heavy context dependency
Society independent	Society dependent
Apolitical	Political
Methods and algorithms	Ad hoc methods
Well-defined problems	Ill-defined problems
Approximation	Estimation is critical
Heavily disciplinary	Interdisciplinary
Problem solutions	Problem descriptions
Few opportunities to practice outside the classroom	Many practice opportunities outside the classroom
Predictable	Unpredictable

- **QR Across the curriculum**

We believe that quantitative reasoning needs to be infused more broadly across the curriculum. The evidence shows that the more broadly represented, the more effectively students learn. While science classes are a good place to study many aspects of QR, there are several QR learning outcomes that should be included in other areas. In particular, we think that following learning outcomes should be included in areas other than the sciences.

1. Discuss quantitative results (e.g. how precise, how reasonable, how typical, how useful) in context of both the problem and general, real-world knowledge

2. Interpret multiple representations of quantitative information and draw inferences from them. Representations of quantitative information can be symbolic (e.g., a formula or symbolic language), visual (e.g., a graph, diagram or schematic), numerical (e.g., a table of values or calculation), or verbal (e.g., written or oral work)

3. Communicate quantitative information effectively incorporating symbolic, numeric, and/or graphical representations and appropriate syntax within verbal and written communication

7. Demonstrate recognition of the value and the limitations of quantitative methods

Communicating quantitatively is an important linguistic skill in which our students need regular practice in order to become fluent. This means that QR needs to be embedded in courses across all the disciplines. In particular, it is necessary for QR to be embedded in a broad range of non-math and science courses, in the same way that it is critical to require writing across the curriculum. We would like to see some QR based learning objectives incorporated in all GenEd courses, with particular emphasis in First Year Inquiry and Junior Seminars.

Appendix: Math Assessment Proposal

Math Assessment and Placement Recommendations
March 2012 (Draft as provided by the Math Area)

Current Process

The Placement Test Currently, an Arithmetic and Skills test, augmented with five basic algebra questions, is administered online to first year and transfer students prior to their arrival for Summer Orientation. The test is part of the Maplesoft/MAA Math Placement Test Suite, developed by the Mathematical Association of America (MAA). It is delivered online using Maple TA, a web-based system testing and assessment system. The Maple TA software is installed on a server maintained by the Tech Center. Prior to adopting the Maplesoft/MAA testing suite in Fall 2006, the College Board's Accuplacer placement tests were administered on campus during the summer, when students selected their courses, and on an as-needed basis during the academic year.

Administration of the Test Most students take the placement test unsupervised at home, and those who don't or who wish to retest do so in the science office, a chaotic environment which serves an office for most of the department's part-time faculty, houses the photocopy machine, and is unsuited to any sort of focused academic work. Although the majority of students take the test online prior to summer orientation, there is no policy dictating when a student must take the test, and it is not uncommon for students to wait until their Junior or Senior year.

Responsibility for Test Administration Since the CLAC I mathematics requirement was instituted in academic year 2002/2003, administration of the placement test has been the responsibility of faculty and staff in the math area.

Placement Process and Cutoff Score Historically, approximately 40% of matriculating students have placed into AE1160. The cutoff score has been set, not on the basis of performance standards but, rather, on budgetary constraints on the number of sections of AE1160 Foundations of Mathematics that could be offered. In other words, we have identified the 40th percentile and set the cutoff score there, and we have occasionally adjusted it in response to changes in enrollment and/or student performance. As a result, many students who manage to avoid AE1160 nevertheless lack the arithmetic and algebraic skills that mathematics faculty consider necessary for success in a college-level math course. Further, for those who do place into AE1160, the criterion for advancing to a college-level course is simply a passing grade, which does not guarantee sufficient preparation.

Use of Test Results by Other Academic Areas Since its inception, test content and set cut scores have been selected by mathematics faculty for a single purpose, namely, to determine which students will be required to take AE1160 Foundations of Mathematics before taking a college-level math course. Over time, however, academic areas other than mathematics have decided to use the placement test results, both implicitly and explicitly, to advise students and set prerequisites for courses. Because they may be using placement test results without knowledge of test content and the rationale for the cutoff score, it might be difficult for them to interpret the meaning of student results. Moreover, the test may not reflect the actual desires of the departments using it, and departments often have differing expectations as to what students need to be competent at -- from computations to variable manipulations. Meanwhile, the math area does not know which

departments are making decisions based on these test results and we often learn after the fact that the test is being used for purposes other than the one intended. The math area receives negative feedback from other departments who express frustration with student mathematical performance upon passing the placement exam or AE1160.

Advantages and Disadvantages Current Test The current online testing program has two main advantages, namely, that administration is not labor-intensive and that students can easily complete the test prior to selecting courses during summer orientation. However, the program has several disadvantages.

1. Because the test is not proctored, the results lack validity. Students do not take the test under the same conditions, and use of calculators cannot be restricted to problems for which their use is appropriate. We have a great deal of anecdotal evidence that some students get help from others, while others do not take the test seriously.

2. The lack of integrity in the test administration process makes it difficult to make meaningfully compare the abilities of students with similar scores, current results to previous years' results, and Curry students' results to those of other institutions.

3. Because the test is somewhat idiosyncratic and is not widely used at other colleges and universities, free and commercial test preparation resources do not exist.

4. The test is not adaptive and is therefore time-consuming to complete. This has prevented us from administering additional tests of elementary algebra or college-level math skills.

5. The exam is a blunt instrument that provides only single global score and no information about students' areas of strength and weakness.

6. Because results are difficult to interpret, advisors and departments are left to speculate as to their meaning. Understandably, they may have unfounded expectations of students' mathematical abilities.

Summary of Recommendations

1. The current placement test should be replaced with a new instrument that is better suited to our needs. Mathematics faculty will recommend a specific instrument by the end of June 2012.

2. The placement test should be administered in a proctored setting on campus during the summer preceding students' first semester or, at the very latest, during students' first semester.

3. Responsibility for administration of the placement test should be assigned to a staff member who is available year round.

4. Placement test scores, instead of completing Foundations of Math, recommended as course prerequisites, with each department determining specific content area scores relevant to their program.

Elaboration/Discussion

1. The current placement test should be replaced with a new instrument that is better suited to our needs.

Tests to be Reviewed Mathematics faculty will review the following placement tests and develop a recommendation by the end of June 2012**.**

- The College Board's Accuplacer placement tests
- ACT's Compass math placement test
- The Aleks web-based assessment and learning system.

Criteria for Test Selection

Ideally, the new placement test will satisfy these criteria:

- It should be adaptive so that it can be administered quickly and efficiently and assess a wider range of content areas.

- It should provide information about students' areas of strength and weakness using content area subscores or clearly articulated proficiency statements that describe students' capabilities. This sort of information would open up the possibility of providing differentiated instruction to individuals or to groups who share weaknesses in a particular content area.

- The test should be widely used so that free and commercial resources are easily available to students for review and study. (A widely used test might also make it possible for students from distant parts of the country and international students to take the test a testing center on another campus.)

- The test should be well-aligned with our general education mathematics curriculum. It also should be sufficiently versatile as to meet the needs of other departments, who could then assume responsibility for selecting content areas and cutoff scores that reflect the content level knowledge they require. For example, quantitatively heavy courses like physics, accounting, and economics could choose to set their prerequisite test scores higher those used for the CLAC I requirement, or they could use specific subscores for content areas relevant to their disciplines (e.g. computation, proportions and percentages, algebraic manipulations.)

2. `The mathematics assessment should be administered in a proctored setting on campus during the summer preceding students first semester or, at the very latest, during students' first term.

Timing of Testing There is abundant evidence that, in the absence of ongoing reinforcement of mathematical concepts, students rapidly lose their mathematical knowledge. Given that many of our students have histories of difficulty with mathematics and a high levels of math anxiety, it is particularly important to address these issues at the beginning of their academic careers. For these reasons, placement testing should occur as early as possible – ideally, prior to their first semester (e.g., during Summer Orientation) and no later than the end of the first semester. We believe that assessment of students is a process that is relevant to the college as a whole and should be integrated into the admissions/first year experience.

Location and Supervision of Testing To ensure that test results are valid, we must ensure the students are taking their own exams with the same resources and under the same conditions. The only way to ensure this is to conduct both initial testing and retesting in an on-campus supervised testing facility. If capacity is adequate, it is possible that the campus computer labs could be used for scheduled testing of large groups of students during orientation. A small, quiet, adequately supervised testing facility would be adequate for testing that occurs during the academic year. Ideally, of course, there would exist a dedicated testing area could be used for other placement tests (e.g., reading and writing). A dedicated facility would make it possible to work with PAL and Student Services to provide accommodations for students whose needs currently are not addressed.

3. Responsibility for administration of the assessment should be assigned to a staff member who is available year round.

ResponsibilitiesThis individual's responsibilities would include such activities as configuring the testing software, consulting with the Tech Center, scheduling of testing, recruiting and training proctors, maintaining a database of results, communicating results to students and advisors, arranging testing and retesting during the academic year, and interaction with mathematics faculty and faculty in other departments that use test results. This person might also play a role in providing resources to help students prepare for the test. Math faculty would, of course, continue to make decisions regarding test content, cutoff scores, and math course prerequisites

Advantages None of these responsibilities require the specialized mathematical knowledge of mathematics faculty, whose time and energy would be better spent in other ways and who are not necessarily available during the peak summer testing period. Assigning primary responsibility for placement test administration to a staff person would make it more like that students are tested in a timely and appropriate fashion, since time constraints of mathematics faculty make it impossible for them to identify students who need testing, contact these students, schedule testing sessions, and follow up when they fail to appear. It should also make it easier for other academic areas that want to set math prerequisites for their courses to provide input into the process.

4. Placement test scores, instead of completing Foundations of Math, recommended as course prerequisites, with each department determining specific content area scores relevant to their program.

Disciplines have different needs and expectations regarding a student's mathematical preparation for their courses. A single placement based math course can not hope to meet all of these competing desires. In addition, some quantitatively heavy courses, like physics or accounting, may desire a higher level of mathematical proficiency than is needed by the average liberal arts student.

Moreover, the learning outcomes of a placement based math course designed for the liberal arts student may or may not correlate with all prerequisite expectations for courses in every other discipline. By making use of placement test subscores, showing student competencies in various areas, instructors can insure the necessary prerequisite skills are there or provide additional assistance in those areas as relevant to their course.

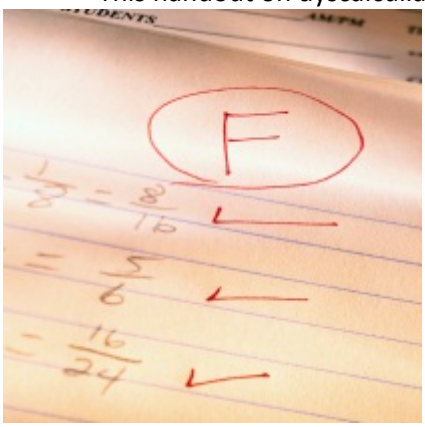
Potential Long-Term Benefits and Other Thoughts

In the absence of a more robust developmental math program and math support services, it is difficult to see how an improved assessment and placement process would make much difference. Hence, once a credible assessment placement process is in place, we will be in a position to make recommendations concerning areas such as test preparation, tutoring and other forms of support, and alternative developmental mathematics pathways. These sorts of services will require more resources, including additional full time faculty, dedicated classrooms designed specifically for mathematics instruction, and well-staffed and well-equipped math support facilities.

Implementation of our proposal would make it possible to provide students with targeted academic support, after which they can retake the placement test. Departments can determine reasonable mathematical expectations for their majors, take responsibility for identifying the mathematical competency level needed for successful completion, and develop programs to assist their students in developing these competencies. The expectation that mathematics faculty should be responsible for ensuring that students meet the specific quantitative reasoning standards of other departmental is not realistic. Three full-time mathematics faculty comprise a relatively small academic area within the Department of Natural Sciences and Mathematics, and we do not have the resources or the release time that are allocated to larger academic departments and programs.

Appendix: Dyscalculia Handout

This handout on dyscalculia was provided to the group by Joe Cullen, PAL Director.



Dyscalculia

Dyscalculia is:

- A Specific Learning Disability that is thought to affect 3- 6% or the general population.
- Operationally defined as extreme difficulty understanding quantitative information despite having normal general intellectual abilities, an adequate home environment, and access to suitable learning opportunities.
- Thought to be due to dysfunction in areas of the brain that process numerical information. Indeed, individuals diagnosed with Dyscalculia typically exhibit mild abnormalities in neuro-psychological testing. However, there is no one cognitive profile that fits all or most individuals diagnosed with the disorder.
- Often compounded by anxiety and strong dislike for math.
- Treatable through educational interventions. While there are many approaches and strategies that are evidence based, the majority involve the following: a) embedding quantitative content in a practical/meaningful context, b) providing extra time and repetition, c) extinguishing anxiety, d) making use of assistive technology, and e) metacognitive strategies.

As a group, PAL students:

- Despite being described as having Language-Based Learning Disabilities, disproportionately indicate that Math is their area of greatest academic challenge.
- And their families have provided strong feedback that our systems of support in Math need improvement.
- Will, in the immediate future, be increasingly challenged in Math due to changes in our admissions process.

Appendix: Embedding QR Handout

This handout was distributed at the Curriculum Innovation Community holiday gathering.

Embedding Quantitative Reasoning

- Lectures & Discussions: Use numbers to provide context; explain their meanings and discuss implications
    - This can involve placing historical figures (50 million people died in the 1918 influenza pandemic "Spanish Flu") in a relevant context (3% of the world's population), assessing the reliability (these figures are a low estimate), and broader implications (how losing this many people affects a society).
    - Make an active effort to use figures relevant to your discipline, for instance:
        - Demographics, survey results, consumer information, nutrition facts
    - Good questions to focus discussions include:
        - **What do the numbers show?**
            - What do the numbers mean? Is there numerical evidence to support a claim?
            - How can seeking and analyzing numbers illuminate important phenomena?
            - How plausible is a possibility in light of back of the envelope calculations?
        - **How representative is that?**
            - Is there wide variability? What's the typical range or margin of error?
        - **Compared to what? What is the context? What information isn't given?**
            - What's the implicit or explicit frame of reference?
            - What's the unit of measurement?
            - What's the order of magnitude?
- Written work: Require quantitative information, such as charts, tables, or demographics to be used for context
    - Grade for coherent use of numbers in sentences, appropriate labels on figures
    - Expect students to use data as part of their arguments
    - See http://serc.carleton.edu/quirk/ for a rubric on grading QR in papers and additional information
- Student Support & Activities: Focus on student understanding of quantitative information and encourage them to use quantitative reasoning where applicable.
    - This can include explaining rubrics and grading schemes to help students understand the impact of low grades or where their study efforts are best spent.
    - Work with students on time management, quantifying the amount of time they need or doing cost-benefit analysis on study habits.
    - Show student groups how to create detailed budget proposals or logistical plans for events.

Appendix: Quantitative Writing

Quick Quantitative Reasoning (QR) Writing Rubric[1]

A rubric to use with papers where the potential uses of numbers can provide useful detail, enrich descriptions, present background, or establish frames of reference.

I. Use of Numerical Evidence To what extent is numerical evidence and quantitative reasoning present in the paper? [**Note**: This is *not* a rating of the quality of the QR shown, only its presence.]

None	No explicit numerical evidence or quantitative reasoning. May include quasi-numeric references (i.e. "many," "few," "most," "increased," "fell," etc.).
Incidental	One or two instances of explicit numerical evidence or quantitative reasoning (perhaps in the introduction to set the context), but no more.
Used	Explicit numerical evidence or quantitative reasoning is used throughout the paper.

II. Quality - Evaluation of the quality of the implementation, interpretation, and communication of QR:

None	Fails to use any explicit numerical evidence to provide context. The paper is weaker as a result. **This paper shows no attempt to employ QR**.
Developing	Uses numerical evidence to provide context in some places, but not in others. The missing context weakens the overall paper. Or the paper may consistently provide data to frame the argument, but fail to put that data in context by citing other numbers for comparison. **Ultimately, the attempt using QR does not achieve its goal.**
Moderate	The paper consistently provides numerical evidence to contextualize the argument when appropriate. Moreover, numbers are presented with comparisons (when needed) to give them meaning. However, there may be times when a better number could have been chosen or more could have been done with a given figure. **In total, the peripheral use of QR effectively frames or motivates the argument.**
Strong	Throughout the paper, numerical evidence is used to frame the argument in an insightful and effective way. When needed, comparisons are provided to put numbers in context. **This paper would be an excellent choice as an example of effective peripheral QR to be shared with students and faculty.**

III. Problems- Problematic characteristics of the QR present in the paper.

Check all issues that detract significantly from the reader's understanding of the information.

_____ Uses ambiguous words rather than numbers.

_____ Uses numerical or quantitative terms incorrectly.

_____ Fails to provide numbers that would contextualize the argument.

_____ Presents numbers without comparisons that might give them meaning.

_____ Presents numbers but doesn't weave them into a coherent argument.

_____ Makes an unsupported claim about the causal meaning of findings.

_____ Doesn't evaluate source or methods credibility and limitations.

_____ Inadequate scholarship on the origins of quantitative information cited.

Quantitative Writing Guide for Students[2]

What do the numbers show?

Don't settle for weasel words like "some" or "many" when precise numbers are available. "Many" people don't suffer from AIDS in the US-over 1 million do.
But don't just settle for any number. Consider whether a particular figure is the right number. Interrogate numbers just as you interrogate texts.
When writing introductions or conclusions to papers, consider how you might use a few well-chosen numbers to establish a context or document the importance of the phenomenon discussed. This is a powerful use of numbers even in papers that are not inherently quantitative. For example, if you are writing a paper that discusses the nature and causes of psychogenic pain, it might help to tell the reader how common (or uncommon) the disorder really is.

How representative is that?

Stories are compelling. But anecdotes can also be misleading. Ask yourself whether a case is typical, and provide evidence to your reader assessing how representative your example is. Is the average appropriate, or are there subgroups or extreme values that present a different picture?

Compared to what?

Is $1 million a lot of money? If it's a salary figure, it puts you in the top 1/2 of 1 percent of US tax filers. But it's only 1/4,000,000 of the US federal budget.
Numbers (especially really big or really small numbers) need context. It often helps to compare them to other better-known figures.

How do the numbers help the argument?

Explain the impact of the numbers used. Do they show how large the problem is? Are they indicating the success (or failure) of a particular approach? Are they suggesting a relationship between two things? How does knowing these figures shape the way you think about the issue?

What's the source of the numbers?

Consider whether the people reporting the figures are credible or if they might have a bias. Also note whether the number comes from a single study or is the result of an entire literature—that is, a collection of studies.

Quantitative Writing
Goals and Objectives

Goals in quantitative literacy (as this skill relates to written argument)[3]:

- How to use data effectively to support a point
- Understand that data can be manipulated to support a point
- See why numbers matter in a political, social, argumentative context
- Get students comfortable with using and questioning numbers as evidence

Objectives:[4]

- Uses numerical and quantitative terms correctly
- States questions and issues under consideration using quantitative information (instead of ambiguous terms)
- Places numbers in context or uses them in comparisons
- Identifies appropriate quantitative or numerical evidence to address questions and issues
- Integrates quantitative or numerical evidence into the argument appropriately

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[1] Adapted from Carleton College's QUIRK program:
http://serc.carleton.edu/quirk/Assessment/index.html
[2] Adapted from Carleton College's QUIRK student guide:
http://serc.carleton.edu/quirk/forstudents/improve_papers.html
[3] http://flightline.highline.edu/english/ideas/ql.php
[4] Some taken from: http://serc.carleton.edu/quirk/assessment/Goals.html

Appendix: Survey and Results

Email to Faculty

The following email went out to the faculty list on 2/14/12 regarding the Quantitative Reasoning Survey.

If you haven't yet please take 5 minutes to complete the survey for the Quantitative Literacy Curriculum Innovation Community (QL-CIC). The link in this email will take you directly to the survey. This link will expire on Friday, February 17th.

https://www.surveymonkey.com/s/9VFW22V

As colleagues, it is essential that we know your thoughts and teaching experiences regarding Quantitative Reasoning (QR). This brief anonymous survey is designed to give us realistic perspectives as we continue our discussions. We want any recommendations we make to reflect the needs and interests of the entire faculty.

Questions regarding QL-CIC or this survey can be directed to the group at QL_CIC@curry.edu or the facilitator, Rebecca Vessenes, at rebeccavessenes@curry.edu.

Thanks,

QL_CIC Affiliates:
Dave Daggett (Math)
Dian Gifford (Academic Affairs)
Tom Gorsuch (Math)
Rob MacDougall (Communication)
Michael Miller (Management)
Eileen O'Connell (Nursing)
Rebecca Paynich (Criminal Justice)
Ed Tallent (Library)
Jerry Touger (Physics)
Rebecca Vessenes (Math)

Instructions

Please answer the following questions to help us learn about faculty perception of Quantitative Reasoning/Quantitative Literacy at Curry. This survey is anonymous and no demographic information is collected.

Definition: Quantitative Reasoning (QR) is a habit of mind to effectively understand, investigate, communicate, and contextualize numerical and graphical information in the evaluation and construction of arguments. QR differs from mathematics and is generally not based on computations and calculations, though they may occasionally be involved.

Survey Questions and Responses

Question 1

How often do you incorporate quantitative reasoning (QR) components into your teaching?

Answer Options		Response Percent	Response Count
Never		9.3%	5
Seldom		14.8%	8
Occasionally		33.3%	18
Frequently		29.6%	16
Every class		13.0%	7
answered question			**54**
skipped question			**0**

Question 2

Which of the following do you use in your teaching (Mark all that apply)

Answer Options		**Response Percent**	**Response Count**
Demographic figures		72.9%	35
Size or numerical comparisons between groups		60.4%	29
Orders of magnitude		20.8%	10
Scaling and/or measuring		39.6%	19
Conversions		22.9%	11
Percentages or ratios		87.5%	42
Frequency		54.2%	26
Correlation		50.0%	24
Histograms or Bar charts		50.0%	24
Other graphical displays		50.0%	24
Pattern recognition		29.2%	14
Changes in quantities over time		47.9%	23
Rates		47.9%	23
Other component requiring quantitative reasoning			11
answered question			**48**
skipped question			**6**

Other responses:

- Erlang C as it applies to CRM
- Statistical inferences, e.g., t tests
- slopes, curves, areas, statistics (StdDev), ratios, RMS, forecasting, ...
- none of these, but we do discuss the results of research.
- Risk analysis; cost: benefit analysis; estimating
- Proportions
- how much real-world activity is quantified, analyzed, and studied
- personal decision making
- I have used anything I've left unchecked, and may again. You name it, I've probably used it.
- Visualization of statistical information
- Basic rhythmic music notation

Question 3

How relevant do you believe QR is to student success in your area?

Answer Options		Response Percent	Response Count
Essential		44.4%	24
Highly important/Very useful		18.5%	10
Somewhat Helpful/Occasionally needed		18.5%	10
Tangentially related		9.3%	5
Not applicable		9.3%	5
answered question			**54**
skipped question			**0**

Question 4

If you answered Not Applicable, what is your area?

- Philosophy and Religion
- Theatre
- English composition, foreign language, and literature
- PAL
- PAL but we have a number of students with math disability so we do address concepts
- It really depends on individual courses; I don't see how this can apply uniformly within the "area" of music. It depends on how deeply the individual course gets into notation issues. Some greatly, others not at all.

Question 5

What concerns do you have about incorporating QR into your classes? (Mark all that apply)

Answer Options		Response Percent	Response Count
Not relevant		13.7%	7
Class time involved		21.6%	11
Not my area of expertise		17.6%	9
Additional faculty workload		11.8%	6
I don’t know how		0.0%	0
Will detract from the course content or focus		5.9%	3
I don't enjoy it		2.0%	1
Concerned about student evaluations		7.8%	4
Concerned about student ability/understanding		35.3%	18
Students won’t see it as relevant		29.4%	15
Student anxiety		25.5%	13
No concerns		37.3%	19
Other (please specify)			9
answered question			**51**
skipped question			**3**

Other Responses:

- I had not previously realized various ways to incorporate QR into all aspects of teaching/learning!
- wont have much impact without clear goals, curriculum, buy-in across college
- I need to know more about it.
- I have a number of students who become extraordinarily anxious whenever they see math
- fear that they will look stupid in public, need for 1-1 tutoring
- QR is fundamental
- Students are encultured in an old-school way of thinking about QR and are impatient problem-solvers.
- none
- again, the answer to this would vary by course.

Question 6

How interested are you in learning how to integrate more QR into your courses?

Answer Options		Response Percent	Response Count
Extremely interested		16.3%	8
Very interested		26.5%	13
Somewhat interested		26.5%	13
Slightly interested		16.3%	8
Not interested		14.3%	7
answered question			**49**
skipped question			**5**

Question 7

If you are at all interested, how would you prefer to learn more? (Mark all that apply)

Answer Options		Response Percent	Response Count
Personal mentoring		13.6%	6
Informal, small faculty presentations and discussions		63.6%	28
Peer support groups		13.6%	6
Excellence in Teaching events		36.4%	16
Summer Institute		27.3%	12
Faculty Retreat		36.4%	16
Online information		29.5%	13
Other (please specify)			3
answered question			**44**
skipped question			**10**

Other Responses:

- Conferences
- wish there was a KhanAcademy.org site for teaching
- I haven't answered 6 and 7 because I already have needed experience and expertise in using QR

Question 8

What benefits do you see to adding QR to your teaching?

(23 responses)

- Widens understanding of the past
- Extremely important for student learning! Quantitative relationships are tools students can apply to all areas of learning - helps with understanding concepts in any area of study
- I do think that it is important for students to get the reinforcement of seeing quantitative reasoning used competently in multiple contexts (just as I think they should and probably do see ethics used in multiple contexts, not only in PHIL courses) .
- I teach almost exclusively first year students so I think it gives them a good foundation for their college courses in the future; can have more in depth conversations with students about data, what it means and how it can inform how we think about issues
- Benefits students in developing more critical thinking skills.
- """Quantitative Reasoning is the antidote to cheap opinions.""--John Hill
- We need more objectivity in my field and in my area at the college."
- It's critical for a criminal justice professional in the 21st century.
- Already teaching it.
- I already use it -- would like to spend less time explaining how to do basic math and quantitative thinking, more time on actually doing it.
- Very little....since I work with demographics and rating scales as a small part of a 1000 level course.
- Provide students with an overall understanding of QR as it relates to a variety of fields.
- Supporting critical thinking in the 21st century!
- Forces the student to engage in a different form of thinking.
- "GREATER student chance to get a JOB once graduated.
- GREATER Curry reputation for training useful graduates.
- GREATER chance students will graduate with better grades."
- It would provide continuity, connection and transference opps.
- Not a lot.
- The ability to do case analysis and make good decisions - NOT just based on "opinions"
- Reinforcing these concepts.
- helps students to see things in perspective
- It will better prepare students for life inside and outside of Curry.
- It is integral to much of what I do.
- Students realizing that they don't have to fear math; students understanding how to translate data to visual diagramming and mapping.
- It is a vital skill for our students. We cannot discuss content without it.

Question 9

Any QR concerns or issues you would like us to know?
(14 Responses)

- I can show them but don't know how to get them to either understand or see relevance
- It needs to be integrated as much as possible throughout the curriculum. It is not just the bastion of the math department.
- How to convince faculty of the overriding value of QR
- A number of my students seem unprepared for even the least rigorous type of quantitative reasoning. For example, I have a number of students at the senior level who are unable to calculate a percentage.
- As a part time faculty, there is no chance to mix with other faculty to discuss teaching techniques on days when I AM ON CAMPUS. It costs me over $50 to travel to campus on my off days according to IRS auto expense rates.
- Too much going on too often to focus on everything. Sum inst is the only way I could focus on this.
- ---
- It does appear to me that the "lights go out" for some students when you push for QR. :-(
- How do multi-section courses ensure that all members are incorporating QR to a relatively equal degree?
- no
- I love teaching it, the trouble is incorporating it into classes that aren't named to support the content. I can only teach it when certain electives run in our program; otherwise I would prefer to have it incorporated into required curriculum.
- Only reason I checked not interested above in 6 is that I feel perfectly comfortable with the degree of QR that is relevant to music notation. Sometimes we get into acoustics, but that's a side topic that can take up time. I use my judgement re how much interest there seems to be on that topic, and how much time we have to "go there."
- Students seem very unprepared for quantitative reasoning and appear to have no interest in how it relates to their work.
- I am extremely concerned about our students' lack of basic skills. Having to stop and teach basic skills (i.e. percentages or rates) detracts from the main message of the course.

Question 10

Any QR success stories or classroom implementations you want to share with us?
(11 Responses)

- nope
- I can't remember any specifics, but I have occasionally been impressed with students showing some initiative and competence in carefully calculating cost-benefit ratios (in an utilitarian ethics case study).
- I think QR is fun.
- Veyre arly in semester -- I ask research students to design and conduct a small survey, in groups. They bring the raw data to class and we do basic statistical analysis as a class exercise. Good way to intro duce the basics.
- I think students learning about audience projections based on quantitative survey is very helpful.
- I have students review KhanAcademy.org video tutorials and Microsoft DreamSpark tutorials on math.
- No.
- Over time the students (are there are many) "get it" at least in regard to case analysis and decision-making.
- This TED lecture has started to reframe my own thinking: http://www.ted.com/talks/lang/en/dan_meyer_math_curriculum_makeover.html
- not in 5 min. or less :-)
- Assignments that show visual works by Curry students.

Question 11

Anything else you want to tell us?
(12 Responses)

- nope
- QR is extremely important and I appreciate the CIC for bringing it to the forefront for teachers/learners. Connections and inter-disciplinary techniques are the way to go!
- Thanks for doing this.
- As an Adviser, I encourage everyone to take Math in their first semester, or first year. So I do applaud any restructuring which would effect this change.
- QL CIC member
- Everyone uses algebra every day almost but they just don't know it. They are scared of the word. Not the tool. How can we make it better for them?
- Overwhelmed. Overwhelmed.
- ---
- There does exist a problem, perhaps, with different learning styles and complete reliance on calculators - but I will take the trade-off.
- It's hard work, but it's important work. We need to break free from students' own conceptions of what's important (not math!) and hold rigorous standards even in the face of student resistance.
- More QR courses should be required, especially for majors for which QR is essential.
- This is an extremely important component of curriculum that I feel could be explored through all the majors.

Submitted 5/10/2012 by Rebecca Vessenes on behalf of QL-CIC.