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Keywords
Quantitative reasoning, Across the curriculum

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Abstract

Educational theorists have argued that effective instruction in quantitative reasoning (QR) should extend across the curriculum. While a noble goal, it is not immediately evident that this is even possible. To assess the feasibility of this approach to QR instruction, I examine papers written by undergraduates for submission to a sophomore writing portfolio. I distinguish papers in which QR is central to the main thrust of the argument ("centrally relevant") from those in which QR would strengthen the argument by providing context, enriching description, or presenting background ("peripherally relevant"). I find extensive potential for QR instruction across the curriculum. In 25% of papers QR was centrally relevant and in another roughly 20% QR was peripherally so. Of papers for which QR is centrally (peripherally) relevant, around 50% (95%) were written outside natural science courses. Moreover, 30% of papers written in arts, literature, and humanities courses were QR relevant.

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Introduction

In his call for reform in higher education, *Our Underachieving Colleges*, Derek Bok (2006) argues that students should encounter quantitative reasoning (QR) throughout the curriculum:

> Like learning to write well or speaking a foreign language, numeracy is not something mastered in a single course. The ability to apply quantitative methods to real-world problems requires a facility and an insight and intuition that can be developed only through repeated practice. *Thus quantitative material needs to permeate the curriculum, not only in the sciences but also in the social sciences and, in appropriate cases, in the humanities*, so that students have opportunities to practice their skills and see how useful they can be in understanding a wide range of problems. (p. 134, emphasis added)

In part, the argument for this cross-cutting approach to QR education rests on a general principle articulated in Shulman (1997 p. 166): "Authentic and enduring learning…can rarely succeed one course at a time." But Steen (2004 p. 18) argues that inter-disciplinary instruction is particularly important to QR due to students' misperception that QR is only relevant to mathematics. "If [QR] remains the responsibility solely of mathematics departments—especially if it is caged into a single course such as 'Math for Liberal Arts'—students will continue to see [it] as something that happens only in the mathematics classroom."

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While these aggressive calls for QR across the curriculum are exciting, it is not immediately clear that they are practical. Numeracy advocates may easily imagine assignments and course modules that teach Steen's (2004 p.9) eloquently described "sophisticated reasoning with elementary mathematics" in the context of history, religion, economics, English composition, physics, fine arts, and other disciplines. But the reality is that leaders of the QR movement only teach a small fraction of those courses. Unless we can show that QR is relevant in the context of courses already being taught on topics already being explored by the professors already in the classroom, substantial progress toward fulfilling the visions of Bok and Steen will be very slow.

Based on a case study of Carleton College, this paper provides evidence that QR is indeed relevant throughout the academy in courses as they are currently taught. Our conception of QR is the habit of mind to consider both the power and limitations of quantitative evidence in the evaluation, construction, and communication of arguments in public, professional, and personal life. (See Grawe and Rutz 2009, Lutsky 2008, and Rutz and Grawe 2009 for fuller discussions of this conception of QR and its implications for professional development and the curriculum.) This understanding of QR situated in the context of argument led us to examine the potential for QR instruction in papers written by students in the first and sophomore years (more or less the general education curriculum).

In the next section I describe the assessment tool and sampling process that generated the data used in the case study.[i] The results, presented in the third section of the paper, are encouraging. Despite predictable differences in the degree to which the college's four divisions—arts & literature, humanities, social sciences, and natural sciences—explicitly require QR in assignments, opportunities to teach numeracy already extend across the entire campus.[ii] In particular

- Over 25% of papers addressed topics for which QR was relevant to a central question, issue, or theme (ie QR was "centrally relevant" to the paper).
- In another 22% of papers, QR was "peripherally relevant"— the use of numbers would provide useful detail, enrich descriptions, present background, or establish frames of reference.
- Thus, in Carleton courses as currently taught roughly 50% of written assignments provide an opportunity for students to engage in QR.
- Of papers for which QR was centrally relevant, over 50% were written outside the natural sciences.
- Of papers for which QR was peripherally relevant, over 95% were written outside the natural sciences and around half were written in arts & literature or humanities classes.
- In total, over one-in-five of papers written for arts & literature and humanities classes were QR relevant (either centrally or peripherally).

Based on the case study, I draw an optimistic conclusion: As currently configured, ample opportunities exist for students to experience and engage in QR across the curriculum.

Method

The data for this study were generated by an application of the QR-in-writing assessment rubric described in Grawe et al. (2010). In particular, I focus on the data generated by two

rubric items: "Is QR potentially relevant to this paper?" and "Does the assignment explicitly call for the use of QR in the paper?"

The possible responses to the first question are:

- No or incidentally only
- Yes, but peripherally only
- Yes, centrally.

The rubric codebook provides the following guidance to scorers:

> This is a reader's assessment of the *potential* contribution of quantitative information to the paper based on the stated and implied goals of the paper itself; it is *not* an assessment of the specifications of the assignment.
>
> In making this assessment, consider how a reasonable person would consider the relevance of QR to the topic chosen by the student. That is, ask if you would expect QR to play a peripheral or central role in a strong paper on this topic, not if you could somehow squeeze QR into this context.

Central uses of quantitative reasoning are the first that come to most readers' minds when contemplating how numbers might be used in arguments. A biology student, citing different genetic markers found among two local populations of gall flies, might argue that geographic separation has prevented mating between the two groups. A sociology student may build a case for the deterrent effects of criminal punishment by comparing crime rates across cities. An art history student might put forward claims about the location of origin for statuary based on a statistical analysis of the metals used in other works of known origin. In each instance, quantitative evidence is at the core of the question--the crux of the argument is inherently quantitative.

But a second category of QR papers, "peripherally relevant" QR papers, is also important to consider. Jane Miller alludes to this in her book *The Chicago Guide to Writing about Numbers*: "Even for works that are not inherently quantitative, one or two numeric facts can help convey the importance or context of your topic…. For both qualitative and quantitative works, communicating numeric concepts is an important part of telling the broader story" (p. 1). I would only add that the peripheral use of quantitative evidence need not be limited to "one or two numeric facts."

Tim Flannery's 2007 *New York Review of Books* review of two books written on recent scientific discoveries from deep oceanic explorations provides a particularly nice example of the use of quantitative evidence to set a context or enrich description.[iii]

> Only the uppermost part of the oceans—the top two hundred meters—bears any resemblance to the sunlit waters we are familiar with, yet below that zone lies the largest habitat on Earth. Ninety percent of all the ocean's water lies below two hundred meters, and its volume is eleven times greater than that of all of the land above the sea. This great realm is divided into a twilight zone—between two hundred and one thousand meters deep—and a zone of total darkness, which is itself varyingly subdivided. Below six thousand meters lies a region known as the hadal zone (a term coined only in 1959

> from the French *Hadès*); in the Marianas Trench off the Philippines it is 11,000 meters deep. Ships plying the waters over the trench glide as far above Earth's surface as do jet aircraft crossing the face of America.

While neither the review itself not the books it surveys deal centrally with quantitative questions, this example demonstrates a richness of description through the use of numerical evidence.

Of course, most students do not write as effectively as Flannery. Nevertheless, nearly all have figured out that claims of prevalence or exceptionality can often motivate reader interest and so introductions are common locations to encounter peripheral QR. For example, a psychology student might introduce a paper on the current understanding of the causal mechanisms for autism by citing statistics showing a recent rise in diagnosis. A philosophy student arguing for a particular definition for what it means to be "poor" may introduce her ideas by noting the recent increase in economic mobility. Or a religion student might introduce a paper on different religious observance by citing polling data on the self-reported religiosity of people in a particular society. None of these papers requires quantitative evidence--such evidence is not at the heart of any of the arguments made and each could have been introduced from a different angle. But the use of quantitative evidence nevertheless frames or motivates the qualitative information to follow.

When scoring the second question—whether QR is explicitly called for in the assignment—raters are given three possible answers: Yes, No, or No Assignment Present. In the norming session that precedes actual scoring, raters are reminded not to make inferences. If the paper is a lab report for which is seems to the reader that QR must have been required, but no physical assignment is present, the proper response is "No Assignment Present." Similarly, even if it seems that an assignment would be best met by using QR but there is no explicit demand for quantitative evidence, the proper response is "No."

Assignments requiring QR typically fall into three groups. Some ask students to use evidence from a provided source, either a specific table or chart of with a reference to a source which contains multiple charts and tables. An example of the former would be an assignment from Introduction to Latino/Latina Studies which asks students to find "stories" within a census table summarizing educational attainment by race and gender. The latter might be an economics assignment asking for a white paper on the employment effects of the minimum wage using both a theoretical model of supply and demand and data of the student's choosing from the Statistical Abstract of the United States.

A second assignment type requires the use of quantitative evidence, but leaves source choices up to the student. For example, a political science paper might ask students to use regression analysis to identify key predictors of border conflicts.

Finally, assignments might require students to collect their own data to analyze. Natural science lab reports immediately come to mind. But a sociology assignment requiring students to keep and then analyze a time diary or a first-year seminar that asks students to tally and explore prevalence of social behaviors at a local city festival would also fit this type.

A team of 21 scorers read papers submitted by students in the 2006 and 2011 graduating classes as part of Carleton's required writing portfolio. Collected from students at the

completion of the second year, these portfolios include three to five essays written in at least two of the four college divisions demonstrating competency in five areas: observation, analysis, interpretation, documented sources, and thesis-driven argument. Students are asked to include copies of associated assignments. I excluded portfolios from students who initially received less than a passing mark when assessed by the writing program (approximately 5% of all students) or who chose not to allow their work to be used for research purposes (roughly 15% of students). From the resulting population, I drew a random 50% sample of portfolios (367 in total). From each of these portfolios, I randomly chose one paper.

While students are asked to turn in assignment handouts for each paper submitted in their portfolio, readers reported finding the assignment in only 38% of cases. Given that two-thirds of papers did not include an assignment, selection bias might contaminate the data if students are more or less likely to include assignments which explicitly require QR. While I cannot test this hypothesis directly because we don't have the assignments that were not turned in, we can look for indirect evidence of selection. For instance, if students are less inclined to turn in handouts for assignments explicitly requiring QR we would likely see relatively fewer natural science papers in the group of submissions including assignments. Table 1 reports the divisional distribution of papers scored by whether students did or did not include an assignment. The data show little difference in divisional representation among papers with and without assignments and a chi-square goodness of fit test fails to reject the null hypothesis that the two distributions are the same ($p = 0.723$).

Table 1. Distribution of division and level of course for which papers were written among papers including and failing to include an assignment handout

Division	With handout	Without handout	Total
Arts and Literature	29.2%	36.2%	33.6%
Humanities	21.9%	19.7%	20.5%
Natural Sciences	14.6%	14.4%	14.5%
Social Sciences	28.5%	24.5%	26.0%
Interdisciplinary	5.8%	5.2%	5.5%
Sample size	137	229	366

Table 2 provides summary statistics for our sample. The demographic data nearly match general enrollment data as one would expect given Carleton's relatively modest drop-out rate. The over-representation of papers written in lower division courses reflects the fact that portfolios are collected at the end of sophomore year. The work examined here might be thought of as coming from the "general education curriculum." In particular, we are not seeing many papers in upper division courses that may be influenced by methods courses required in quantitative majors. Finally, the data show a bias toward work done in the humanities and away from that done in the natural sciences. Whereas roughly 15% of courses taken by these students were in the humanities, 21% of papers in our sample were written in these courses. As a consequence, despite the fact that approximately one-quarter of courses taken were in the natural sciences under 15% of the papers originated from these disciplines. In part this pattern reflects the fact that writing assignments are more prevalent in the former departments than in the latter.

Table 2. Summary statistics describing students who wrote scored papers and courses for which the papers were written

Student demographics			
Sex		*Ethnicity*	
Male	46.3%	White	79.3%
Female	53.7%	African American	2.7%
		Hispanic	5.2%
		Asian	7.9%
		No response or other	4.4%
Course characteristics			
Level		*Division*	
Lower	70.0%	Arts and Literature	33.6%
Middle	26.9%	Humanities	20.5%
Upper	3.1%	Natural Sciences	14.5%
		Social Sciences	26.0%
		Interdisciplinary	5.5%
Sample size	367		

Results

One way to explore the relevance of QR across the curriculum is to ask how frequently assignments in each division explicitly require the use of quantitative evidence. Table 3 summarizes the propensity for assignments to call for QR, separated by divisions. The first row reports statistics for all of the papers in our sample which included an assignment. Around one-third of these papers explicitly require QR, but predictable disparities exist across disciplines. In particular, fewer than 10% of arts, literature, and humanities assignments require students to engage quantitative evidence. By contrast, among natural science papers two-thirds of assignments demand arguments involving numbers. Social science assignments fall in the middle with roughly one third calling for QR. The second row of Table 3 presents results for lower-level courses. It appears that QR might be required more often in lower level courses in the humanities and natural sciences. As the sample size grows with future assessment this question should be revisited.

Table 3. Percent of assignments explicitly requiring QR, by division for which paper was written

Arts & Literature	Humanities	Natural Sciences	Social Sciences	Inter-disciplinary	All
All assignments					
0.0%	13.3%	65.0%	30.8%	37.5%	23.4%
(40)	(30)	(20)	(39)	(8)	(137)
Assignments written for lower-level courses					
0.0%	20.0%	81.8%	34.5%	37.5%	25.5%
(32)	(20)	(11)	(23)	(8)	(94)

Note: Number of observations in parentheses.

Viewed through the lens of assignments explicitly calling for students to engage with quantitative evidence, the data paint a bleak picture for those attempting to permeate the

curriculum with QR. With less than 10% of papers written in traditionally "non-quantitative" disciplines requiring QR it might seem difficult to convince faculty in the arts, literature, and humanities to spend any of their scarce time thinking about how to improve numeracy among students. What is more, the data on QR-explicit assignments seem to suggest that QR program directors (or others charged with implementing QR graduation requirements) have little benefit in reaching out to faculty in these disciplines. Among papers assignments requiring QR, 41% fall in the natural sciences and another 38% are written in the social sciences. With only 22% of QR-required papers written in the arts, literature, and humanities it might seem foolish to invest resources into programming designed to help faculty in these fields to teach numeracy more effectively.

I would argue that these conclusions are incorrect because important opportunities to teach and learn QR are missed by an approach that focuses solely on the explicit demands of assignments. Regardless of the paper prompt, students may well approach a topic from an angle for which QR is relevant. An examination of the paper topics chosen by students shows extensive opportunity for numeracy instruction in all divisions of the college. Table 4 presents the fraction of papers written in each of the disciplines, dividing the data by the relevance of QR to the argument as approached by the student.

Table 4. Percent of student papers for which QR is relevant, by division for which paper was written

Arts & Literature	Humanities	Natural Sciences	Social Sciences	Inter-disciplinary	All Papers
Centrally relevant					
3.3%	6.7%	84.9%	38.3%	20.0%	25.8%
(4)	(5)	(45)	(36)	(4)	(94)
Peripherally relevant					
16.3%	22.7%	7.5%	35.1%	30.0%	21.9%
(20)	(17)	(4)	(33)	(6)	(80)
Either centrally or peripherally relevant					
19.5%	29.3%	92.5%	73.4%	50.0%	47.7%
(24)	(22)	(49)	(69)	(10)	(174)
Irrelevant					
80.5%	70.7%	7.5%	26.6%	50.0%	52.3%
(99)	(53)	(4)	(25)	(10)	(191)
All					
100.0%	100.0%	100%	100.0%	100.0%	100.0%
(123)	(75)	(53)	(94)	(20)	(365)

Note: Number of observations in parentheses. The sample size in this analysis is smaller than that for the sample as a whole due to transfer courses and off campus studies courses which do not fall into any of the divisional categories.

The first row shows the percent of papers for which QR was centrally relevant—potential uses of numbers address a central question, issue, or theme. Because the fraction of centrally relevant papers within divisions almost matches that of QR-required assignments reported in Table 3, one might wonder whether the category of papers for which QR is centrally relevant is equivalent to the category of papers written to assignments for which QR is explicitly required. Table 5 shows that there is considerable overlap with the central

relevance of QR correctly predicted by the assignment category in 84% of all cases for which the assignment is available. Still it appears there is an important and substantial group of papers outside this overlapping region: Among centrally relevant papers over one- third were written to assignments that did not explicitly demand quantitative evidence.

Table 5. Overlap between papers for which QR is centrally relevant and papers written to assignments that explicitly require QR

	Assignment requires QR?		
Centrally QR relevant?	**No**	**Yes**	**All**
No	87.9% (94)	27.3% (9)	73.6% (103)
Yes	12.1% (13)	72.7% (24)	26.4% (37)
All	100.0% (107)	100.0% (33)	100.0% (140)

Note: Number of observations in parentheses.

The large fraction of natural science papers requiring QR might seem to support a narrow QR curriculum housed in mathematics and natural sciences. But looking at the data in Table 4 we see that over 50% of papers for which QR is centrally relevant were written for courses outside these departments. If students' experiences with central QR arguments are as often outside math and natural sciences, then QR professional development must extend beyond these divisional boundaries as well or students will suffer from inconsistent teaching messages.

The second row of Table 4 presents the fraction of papers written in each division for which QR is peripherally relevant—given the way the student has written the paper the use of quantitative evidence could potentially strengthen the work by providing useful detail, enriching descriptions, presenting background, or establishing frames of reference. This data presents an entirely different picture of where QR is happening in the curriculum. First, natural science papers almost never fall in the peripherally relevant category because nearly all papers written in these fields take up an issue for which QR is centrally relevant. As a result, 95% of opportunities to engage QR in a peripheral way occur outside the natural sciences. Second, roughly one-sixth of papers written in the arts & literature and nearly one-quarter of papers written in the humanities approach their topics in such a way that an engagement with quantitative evidence would be helpful to set a context or provide detail.

To understand better how QR can and does inform papers in arts & literature and humanities courses, consider several examples. A first year English composition assignment asks students to argue for a definition of poverty based on three philosophical arguments read by the class. In introducing her paper, a student "hooks" her audience with reference to the disparity in incomes between the rich and the poor. In this case, while the student did not need to use quantitative reasoning (for instance, one might easily imagine starting a paper of this sort with a compelling non-quantitative quote), her decision to contextualize the philosophical debate with quantitative concepts introduces an opportunity to teach the peripheral use of QR. All too often students write sentences like, "There are vast wealth differences between the rich and the poor." This imprecise claim can be vastly improved by

finding actual data: "In the United States today, the top 1% of households control twice as much wealth as the bottom 80%."

While such peripheral use of QR might be the more common mode of quantitative reasoning in the arts, literature, and humanities, there are cases in which QR is centrally relevant. For instance, Lac (2010) documents an assignment in her French culture course in which she asks students to compare and contrast the representation of cultural topic such as education or social integration in both social statistics and movies. Lac writes, "By integrating socio-economic data analysis and the study of the movie, students evaluate the worth of the fiction as a faithful or distorted mirror of its society." In a rich experience with data, Lac's students are invited to consider a very important qualitative question: What is the meaning of fiction?

Discussion

The results presented above support the curricular models advocated by Bok and Steen. We believe the data point to two important lessons. First, QR is relevant to courses outside the natural sciences as they are currently taught. Readers may not be surprised to learn that students regularly engage QR-relevant topics in the social sciences: Roughly 75% of papers written in these departments are QR-relevant and just under 40% are centrally so. If numeracy programs have not already engaged faculty in this group, social scientists would seem to represent a great place to begin building broader campus support.

While social science faculty may be ready allies, I would call particular attention to the role of QR in the arts, literature, and humanities. Apparently the general education curriculum as presently configured provides ample opportunity for students to engage in numeracy across the campus. Enticing faculty in these traditionally non-quantitative fields to take up the QR banner will likely require active recruitment. In particular, since less than 10% of assignments in these divisions explicitly call for QR and a similarly small fraction of papers take up topics for which quantitative evidence plays a central role, I suspect that many faculty in these courses will need to be shown how QR enters arguments in their classes. While the results from this case study might be useful information, it may be more effective to provide examples from actual student work and to draw parallels between the rhetorical uses of numbers we wish to encourage and other rhetorical issues faculty are already aware of. For example, urging students to use actual quantitative evidence rather than rely on quasi-numeric phrases like "many," "few," or "some" can be equated with promoting precision in language or requiring evidence for claims. In other words, we may need to "repackage" the QR discipline to make clear that it complements existing teaching goals in disciplines which view themselves as "non-quantitative."

People looking to take on this recruitment challenge might find useful the National Numeracy Network's module on designing QR-in-writing assignments.[iv] In addition to providing tips for assignment creation (originally written by Seattle University's John Bean), the module currently includes a collection 68 examples drawn from 18 disciplines including American Studies, Classics, English (2), Fine Arts, History (2), and Languages (3). The uniform presentation of assignments makes the collection easy to browse so that assignments in the social sciences, for example, might yet provide the seed for innovation in the humanities. Each assignment in the collection is presented in the same format. After a brief summary of the assignment, the webpage articulates the learning outcomes for the assignment. The remainder of the page describes the assignment in detail, shares

evaluation tools such as grading criteria or rubrics, and shares "teaching tips"--a virtual equivalent to the oral advice one colleague might share with another when passing on an assignment.

The second lesson derived from the data is that natural scientists are unlikely to reform QR attitudes and aptitudes across the campus on their own. There is simply too much QR going on in other divisions for this strategy to hold much hope. When peripherally relevant papers are included, fewer than one-third of QR-relevant papers were written for courses in the natural sciences—the same fraction as that in the arts, literature, or humanities courses. Even among papers for which QR was centrally relevant, half were written in other divisions. And of papers for which QR is peripherally relevant, more than half were written in the arts, literature, or humanities. This means that if natural scientists attempt to "go it alone," students will receive conflicting messages concerning the power of quantitative evidence in arguments. On some assignments, students will hear that QR is very important while on others they will learn that inattention to numeracy has no consequence. As a result, some students will leave our campuses without an appreciation for the power of numerical thought. Worse still, many will come to understand that QR is relevant only to those pursuing careers in a narrow set of fields—an outcome against which Steen (2004 p. 18) rightly warns.

Some may argue that the peripheral use of QR is not "real" numeracy. I would argue against this perspective for four reasons. First, there is no limit on the sophistication of skills that might be employed in a peripheral way. While many peripheral uses of quantitative evidence may involve citing a simple mean, it is entirely plausible that a student could reference the results of an advanced statistical analysis as a way of providing detail or context. This is a particular instance of a broader argument made by Steen (2004 p. 16): "[QR] functions at many levels, and no matter how much is accomplished … there will be much to pursue at the tertiary level that is every bit as sophisticated and subtle as other subjects that students study in higher education." That QR is peripheral need not mean it is simplistic.

Second, effective peripheral use of QR often addresses questions which others have argued are "foundational" to quantitative literacy like, "What do the numbers show?", "How representative is that?", and "Compared to what?"[v] In fact, it may be more effective to teach students to ask these questions in a peripheral context where the details of more complex analytical tasks associated with central use are absent.

Third, I believe we must view students' QR educations as a journey through many courses rather than as a destination arrived at in a single class. The peripheral QR skills that may be taught in many arts, literature, and humanities courses are surely not all of the numeracy capacities we desire our students to obtain. But developing foundational skills and habits of mind in these courses prepares students for deeper, more sophisticated applications in other courses in which more formal QR methods are the focus.

Finally, I speculate that repeated encounters with peripheral QR applications in arts, literature, and humanities courses might reduce math phobia. Colwell (2003) and Steen (2001 p. 8) have argued that the QR discipline in general can serve to knock down the barriers of math fears. It would seem that for many students facing this struggle, repeated encounters with peripheral QR would be especially powerful. I hope future research can confirm this hypothesis to guide and motivate further curricular reform.

In *Achieving Quantitative Literacy*, Richardson and McCallum (2004 p. 17) opine, "Quantitative literacy cannot be taught by mathematics teachers alone...because quantitative material must be pervasive in all areas of students' education." This goal, echoed by Bok (2006), Steen (2004) and others, is only possible if professors teaching "most courses" view quantitative reasoning (QR) as relevant to their classes and their course goals. The results of this study suggest that Steen's goals are achievable.

References

Bok, D. (2006). *Our underachieving colleges: A candid look at how much students learn and why they should be learning more.* Princeton, NJ: Princeton University Press.

Colwell, R. (2003). Quantitative literacy goals: Are we making any progress? In B. L.Madison and L. A. Steen (Eds.), *Quantitative literacy: Why numeracy matters for school and colleges* (pp. 243-246). Washington, DC: National Council on Education and the Disciplines.

Grawe, N. D., & Rutz, C. A. (2009). Integration with writing programs: A strategy for quantitative reasoning program development. *Numeracy*, 2(2), Article 2.

Grawe, N. D., Lutsky N. S., & Tassava, C. J. (2010). A rubric for assessing quantitative reasoning in written arguments. *Numeracy*, 3(1), Article 3.

Lac, C. Cultural reading of movies in an advanced culture class in French. Accessed at http http://serc.carleton.edu/nnn/quantitative_writing/examples/33554.html on October 15, 2010.

Lutsky, N. S. (2008). Arguing with numbers: Teaching quantitative reasoning through argument and writing. In B.L. Madison and L. A. Steen (Eds.), *Calculation vs. context: Quantitative literacy and its implications for teacher education* (pp. 59-74). Washington, DC: Mathematical Association of America.

Lutsky, N. S. 10 foundation quantitative reasoning questions. Accessed at http://serc.carleton.edu/quirk/CarletonResources/10questions.html on October 15, 2010.

Richardson, R. M., & McCallum, W.G. (2004). Embedding QL across the curriculum. In L. A. Steen (Ed.) *Achieving quantitative literacy: An urgent challenge for higher education* (p. 17). Washington, DC: The Mathematical Association of America.

Rutz, C. A., & Grawe, N. D. (2009). Pairing WAC and quantitative reasoning through portfolio assessment and faculty development. *Across the disciplines*, December.

Shulman, L. S. (1997). Professing the liberal arts. In R. Orrill (Ed.), *Education and democracy: Re-imagining liberal learning in America* (pp. 151-173). New York, NY: The College Board.

Steen, L. A. (2001). *Mathematics and democracy: The case for quantitative literacy.* Washington, DC: National Council on Education and the Disciplines.

Steen, L. A. (2004). *Achieving quantitative literacy: An urgent challenge for higher education.* Washington, DC: The Mathematical Association of America.

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[i] Grawe, Lutsky, and Tassava (2010) provide a complete description of the assessment rubric and document its reliability across raters.

[ii] Our mapping of departments to divisions is as follows:
Arts & Literature: Arabic, art history, studio art, Asian languages, cinema and media studies, Chinese, classics, dance, English, French, Francophone studies, German, Greek, Hebrew, Japanese, Latin, literary and cultural studies, media studies, music, Russian, Spanish, and theater
Humanities: history, philosophy, and religion
Natural Sciences: astronomy, biology, chemistry, computer science, geology, mathematics, and physics
Social Sciences: archeology, economics, linguistics, political science, psychology, and sociology/anthropology
Interdisciplinary: African-American studies, cross-cultural studies, cognitive studies, environment and technology studies, European studies, interdisciplinary studies, Latin-American studies, and women and gender studies

[iii] We thank Kristin Partlo for bringing this example to our attention.

[iv] http://serc.carleton.edu/nnn/quantitative_writing/index.html

[v] These are three of Lutsky's (2010) "10 Foundational Quantitative Reasoning Questions."