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1-4-2012

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Recommended Citation
Diefenderfer, Caren (2012) "The Joy of Quantitative Reasoning," Numeracy: Vol. 5: Iss. 1, Article 1. DOI: http://dx.doi.org/10.5038/1936-4660.5.1.1 Available at: http://scholarcommons.usf.edu/numeracy/vol5/iss1/art1

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Numeracy
Advancing Education in Quantitative Literacy

Volume 5 | Issue 1 Article 1

1-4-2012

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Diefenderfer, Caren (2012) "The Joy of Quantitative Reasoning," *Numeracy*: Vol. 5: Iss. 1, Article 1.
DOI: http://dx.doi.org/10.5038/1936-4660.5.1.1
Available at: http://scholarcommons.usf.edu/numeracy/vol5/iss1/art1

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The Joy of Quantitative Reasoning

Abstract
One of the advantages of focusing on quantitative reasoning is that it spans a wide variety of topics. As incoming president of the National Numeracy Network, I would like to take the opportunity of this editorial to tell my story of intellectual reward from finding common purpose in quantitative reasoning with colleagues from disciplines outside of mathematics. The story starts with an NSF-funded faculty development project (DUE-9952807) to further a QR across-the-curriculum program and the finding from that program that merging authentic context with mathematics brings interaction and collaboration. That joy in learning from and working with colleagues in other disciplines has now expanded to seeking authentic context for all of my mathematics courses and being open to new ways of thinking.

Cover Page Footnote
Caren Diefenderfer is a professor of mathematics at Hollins University where she has chaired the mathematics and statistics department as well as the division of natural and mathematical sciences. She served as Chief Reader for AP Calculus, 2004-2007. She is president of the National Numeracy Network, which publishes this journal.

This editorial is available in Numeracy: http://scholarcommons.usf.edu/numeracy/vol5/iss1/art1

I started working with colleagues at Hollins on a Quantitative Reasoning program in 1998. Our vision was to allow students to choose a quantitative reasoning course in a discipline of their choice in order that their quantitative work would be critical to a topic that was important to them.

In order to help faculty members develop quantitative reasoning projects in disciplinary courses, Professor Trish Hammer and I applied for and obtained an NSF Faculty Development grant.[1] The grant allowed us to bring four visiting scholars to our campus. We expected our colleagues to revise ideas that the visiting scholars described. Instead, our colleagues showed great creativity and originality in designing quantitative reasoning projects. The first thing we observed was that the projects they created during the workshops were both more interesting and sophisticated than the "applied" exercises that frequently occur at the end of problem sets in mathematics textbooks. Our colleagues' projects demonstrated that there is a serious problem with the applied exercises in our textbooks. I had thought that such applied problems would help students understand that learning specific mathematical concepts is important for life. But, the applied problems in the textbooks lacked an authentic context. Students, on the other hand, are familiar with authentic contexts from their work in the sciences, the social sciences, the arts and the humanities.

A second observation about the QR projects designed by my colleagues is that they often involved elementary mathematics and sophisticated reasoning. The main importance of these projects to mathematics is that they demonstrate to students that authentic quantitative problems appear in all disciplines.

I will give a short description of three of the Hollins quantitative reasoning projects in order to explain the authentic contexts that we have developed.

- Professor Andre Spies taught a course titled "France since the Revolution," before he retired in 2004. The quantitative reasoning project Professor Spies designed relies on an 1869 document of Minard that gives a visual schematic of Napoleon's march to Moscow and his return.[2] Professor Spies wrote a series of questions that is intended to help students understand the disastrous nature of this event. Students must pay close attention to the numerical information on the schematic (including the temperature in Reaumur) to draw important conclusions about the march. Students agree that this exercise is more interesting than simply reading about the event in a textbook.

[1] DUE-9952807 (2000–2003).

[2] Minard's "flow map" is a featured picture on Wikipedia. See http://en.wikipedia.org/wiki/File:Minard.png (accessed December 16, 2011).

- Professor Ruth Doan teaches a course in U.S. Social History and shows students a 1689 census from Bristol (now Rhode Island). Students work together to understand how the data are organized. Professor Doan uses this assignment so that students can develop a strong sense of "family" in colonial New England. Males were the head of most households, but by carefully observing the household of the Widow Walley, students learn who is and is not included in the census numbers. Another interesting detail of this census is that they list 421 souls and then include two additional names. We don't know why these two men were not counted as "souls." Students give theories and must decide if this is a significant issue or a mild annoyance.
- Professor Tine Salowey teaches a course in Ancient Art and uses a text of Vitruvius to study the floor plan and 3d elevation of ancient temples. Students use measurements from a small temple fragment to recreate an entire structure based on Vitruvius' text.

These three projects exemplify the way in which the Hollins quantitative reasoning projects apply to a specific discipline and require students to apply elementary mathematical models and use sophisticated reasoning to complete the assignment.

What makes many of the QR projects successful is that instructors have developed a scaffolding approach to the final assignment. Most instructors include group work, class discussion and individual writing as part of the project. Several instructors believe that having students create the data (by a survey or by visiting a site) gives students true ownership of the project. Instructors also encourage students to approach the problem from multiple points of view.

As a result of working with faculty in developing QR projects, I continue to look for authentic contexts for problems that are connected to the courses that I teach in Quantitative Reasoning, Linear Algebra, and Writing Proofs. I am especially pleased to be a Co-PI on Bernie Madison's "Quantitative Reasoning in the Contemporary World" NSF grant. As part of this grant, the QRCW team produced a book[3] of case studies in the news that serves as the framework for an introductory quantitative reasoning course.[4] We have identified 30 news articles from a variety of sources that address health, public policy, tax bills, and personal

[3] Madison, B. L.,S. Boersma, C. L. Diefenderfer, and S. W. Dingman. 2009. *Case studies for quantitative reasoning: A casebook of media articles*, 2nd edition. New York, NY: Pearson Custom Publishing.

[4] Described by the QCRW team in a series of papers in this journal, most recently: Boersma, S., C. Diefenderfer, S.W. Dingman, and B.L. Madison. "Quantitative Reasoning in the Contemporary World, 3: Assessing Student Learning," *Numeracy* 4(2); Article 8.

DOI: http://dx.doi.org/10.5038/1936-4660.5.1.1

finance. One of the nicest parts of this course is that students never ask the proverbial question, "When will I ever use this?"

In addition to looking for authentic contexts for quantitative problems, my work with colleagues in a variety of disciplines has encouraged me to be open to exploring new ways of thinking. Several years ago, Robert and Michele Root-Bernstein came to our campus to talk about their book, *Sparks of Genius.*[5] The Root-Bernsteins suggest that by practicing observing, imaging, abstracting, recognizing patterns, forming patterns, analogizing, body thinking, empathizing, dimensional thinking, modeling, playing, transforming, and synthesizing we can become more creative and better at interdisciplinary thinking. I have used several of their ideas with both my first-year seminar and a faculty development group.

As a result of this work, I have been thinking about thinking in new ways. As a treat to myself, when I became a full professor in the spring of 2005, I joined a Steel Drum Band. I have been playing the bass drums, which means that I have six drums, each of which has three notes on them. I've played the piano since 3rd grade and in addition, I've also been a member of church and school choirs. Reading music has become second nature to me. However, there was one day at steel drum practice when I simply couldn't find any of the notes and I worried about whether I had forgotten how to read music. I decided to come home and see if I could play the score on a keyboard and discovered that I could easily read and play the music. As I considered what had gone wrong at practice that day, I realized that until learning to play steel drums, all of my musical experiences relied on a linear scale. When I play the piano, I know that I'll find low notes toward the left of the piano keyboard and the high notes at the right of the piano keyboard. Similarly, when I sing, I can follow the staff and move from low pitches to higher ones (or lower ones) by following the direction of the notes on the staff. But, the notes do not appear in a linear order on the six bass drums that I play. I realized that the songs I knew the best were ones where I had unconsciously choreographed a dance and was experiencing the Root-Bernstein technique of body movement (or muscle memory) as I played.

I sincerely believe that being able to understand new paths of thinking and helping my students to find the path that makes sense to them is a direct result of my work in quantitative reasoning with faculty members from disciplines across the curriculum. The faculty development workshops that I led with my colleague Trish Hammer showed us that even though we do have different ways of defining and approaching problems, by honoring one another's work we open up new doors for everyone and we experience the joy of discovery together.

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[5] Robert Scott Root-Bernstein and Michele Root-Bernstein, *Sparks of Genius: The 13 Thinking Tools of the World's Most Creative People*, Houghton Mifflin, 1999.

My message to QR faculty is this: Look beyond your department and your usual comfort zone. Find colleagues on your campus who are involved in interesting work. Invite them to go for lunch or coffee, listen to their thoughts, and learn about the projects that interest them. One of the advantages of focusing on quantitative reasoning is that it spans a wide variety of topics. The NNN, for example, is currently planning its 2012 annual fall meeting, "QL at Work: Navigating the Worlds of Journalism, Finance, Business and Citizenship." The meeting will be October 12-14 in New York City. I hope you will be able to attend and that you'll create time between now and then to become involved with or expand on a quantitative reasoning project that connects with one of our meeting's focus areas. We are anxious to hear about your work. Details on this meeting, including a Call for Papers, will appear on the NNN Web site.[6]

Working with colleagues on my own campus and in the NNN network has been a positive, fun and energizing professional activity for me, and I hope you will either start or continue your journey on this path in 2012.

[6] http://serc.carleton.edu/nnn/index.html (accessed December 16, 2011).

DOI: http://dx.doi.org/10.5038/1936-4660.5.1.1