Teaching Quantitative Skills in a Geoscience Context

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A Workshop Creating Partnerships

Improving students' quantitative skills can be most effectively accomplished using an integrated approach creating synergies between mathematics, geoscience and other science courses. This summer 36 mathematics and geoscience faculty met at Carleton College for a four day NAGT workshop to explore the ways in which geoscience and mathematical approaches to teaching quantitative skills complement each other and to develop materials that reflected the strengths of both approaches. Funding was provided by the National Science Foundation. This poster and the workshop website provide resources created by workshop leaders and participants to help faculty in math and geoscience to be more effective in developing their students' quantitative skills.

Why are quantitative skills important?

At the introductory level, geoscience courses play an important role in teaching students the basic abilities needed to use and understand quantitative information. These skills are becoming more important as quantitative information is increasingly used by all citizens to make informed personal choices, for financial success, and to guide our democracy (Mathematics and Democracy, Steen, 2001). Mathematical skills are also becoming increasingly fundamental to success as a practicing geoscientist requiring new emphasis within the major.

What do we mean by quantitative skills?

Geoscience faculty teach quantitative skills in two fundamentally different contexts. At the introductory level, we must ask the question, what quantitative skills are important for the full range of students enrolled in these courses, many of whom will have little further scientific training. A particularly important population in these courses is those students who will become teachers. In thinking about majors, it is important to consider our goals for these students and the diversity of their future career pathways.

Quantitative Literacy

The Mathematical Association of America in their document Quantitative Reasoning for College Graduates suggests that every college graduate should be able to apply simple mathematical methods to the solution of real-world problems.

A quantitatively literate college graduate should be able to:

- Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
- Represent mathematical information symbolically, visually, numerically, and verbally. Use arithmetical, algebraic, geometric and statistical methods to solve problems.
- Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.
- Recognize that mathematical and statistical methods have limits.

There is much less consensus on what skills are needed for geoscience majors.

Critical Aspects for Teaching

Mathematics educators have developed considerable evidence that mathematical concepts are best understood when:

- The concept is introduced with multiple representations (graph, equation, language, visualization)
- In-depth problems are used to explore the concepts and their application
- Contextual examples are an explicit part of teaching
- Students have opportunities to work in group and discuss their thinking

New Resources for Faculty

A Vocabulary for Discussing Quantitative Skills

Sam Patterson, Professor of Mathematics at Carleton College is leading an effort to define the topics and higher order thinking skills that are important in the geosciences. An initial list is available on the workshop website (serc.carleton.edu/quantskills/events/NAGT02/). We are using it determine what quantitative skills are used in different parts of the geoscience curriculum and as a basis for cataloging teaching resources in the DLESE Teaching Quantitative Skills in the Geosciences collection (serc.carleton.edu/quantskills).

New Teaching Materials

Workshop participants worked in teams that included both geoscientists and mathematicians to pool their expertise and develop teaching materials. Available on the workshop website, these include:

- **The Carbon Ballpark Series**, Christoph Geiss, Tim Kroeger, Colleen Livingston
- **Darcy's Law for Multiple Levels in Math and Geoscience Courses**, Steve Leonhardi, Cathy Summa
- **Developing Regional Curves of Stream Hydraulic Geometry** and **Radiometric Dating**, Jim Sochacki, Scott Eaton, Richard Ford, Peter Kohn, Christopher Gellasch
- **Introduction to Population Growth; Example of Exponential Increase in Atmospheric CO2 Concentrations**, Carol Ormand, Linda Eroh, Maureen Muldoon, Jennifer Wenner
- **Isostatic Uplift and Subsidence of Crustal Blocks and Cross Sectional Area of a Morphologic Feature Above Sea Level**, Albert Hsui, Ping Wang, Will Frangos
- **Floods on the Minnesota River - Planning for St. Peter,** Carolyn Dobler and James Welsh
- **Template for Using Functions in an Intro Geology Class**, Carol Ormand, Linda Eroh, Maureen Muldoon, Jennifer Wenner
- **Theory of the Vertical Structure of the Atmosphere and Oceans**, Bill Capehart, Patty Crews, Nadina Duran-Hutchings, Jay Hutchings, Denyse LeMarie, Hieu Nguyen, Alan Shapiro
- **Application of the Three Point Problem**, Bruce Herbert, Vince Schielack, Michael Jordan, Marvin Bennett, Margie Mason

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