

Teaching Quantitative Skills in the Geosciences: Resources for Faculty

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Quantitative Concepts & Geoscience Context

Increasingly students must use and understand quantitative representations. Over the past ten years, four workshops have explored the importance of quantitative skills and effective methods for teaching them in the geosciences. Early workshops recognized two sets of issues - quantitative literacy in introductory classes and quantitative skills in upper level courses - and explored the breadth of skills associated with the geosciences. Last summer, geoscientists gathered to create examples demonstrating how they teach quantitative skills to geoscience majors that could be shared widely through the website. The outcome of all four of the workshops is a collaborative effort to develop and disseminate teaching materials and strategies that link *the best practices* from the mathematics, education and science communities to the teaching expertise of geoscience faculty who are leaders in this field.

To continue this work, there will be two additional disciplinary workshops in the summer of 2005 (geomorphology and atmospheric science). Faculty participating in these workshops will develop further examples of instruction in upper division courses for dissemination via the website. Workshop participants will bring an activity that has been used successfully in their teaching, refine this activity based on reviews by other participants, and create the supporting materials for the website. Further information about the workshops will be found on the website in mid-January.

What do we mean by quantitative skills?

Geoscience faculty teach quantitative skills in two fundamentally different contexts. At the introductory level, faculty teach quantitative skills to students who may encounter little science later in their academic career. Thus, emphasis is placed on increasing quantitative literacy - the ability to function in a number-rich society. In upper level courses, faculty focus on specific mathematical skills within the subdisciplines of geoscience, preparing students for the quantitative rigors of a career in geoscience.

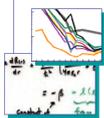
Why teach quantitative skills in a geoscience context?

The geosciences provide a rich resource of context for teaching quantitative concepts. The geosciences provide numerous examples of interesting real-world problems that emphasize a number of important quantitative skills (including numerical manipulation, graphical abilities, problem-solving and critical thinking). As both the geosciences and society are becoming increasingly quantitative, it is important to prepare quantitatively literate citizens at all levels of the geoscience curriculum. The geosciences provide exciting opportunities to increase the quantitative literacy of all students.

Good Teaching Ideas from the Math/Geoscience Communities

During the workshop in 2002, geoscientists and mathematicians worked together to develop these “good ideas” for teaching mathematical concepts:

1. Use multiple representations



Linking of multiple representations (symbols, images, numbers and words) to concepts has been shown to increase conceptual development and problem-solving abilities (e.g., Schultz and Waters, 2000).

2. Use appropriate technology



Calculators and computer programs give students dynamic means to gaining intuitive understanding of connections among multiple representations (Pea, 1987).

3. Work in groups



Numerous studies show that student learning is enhanced when students actively engage in and discuss quantitative exercises with other students (e.g., Ahmadi, 2002).

4. Do in-depth problems that last more than one day



Real-world problems are rarely “solved” in one class period. Giving students problems that span several class periods allows them to internalize and develop useful problem solving skills.

5. Place mathematical concepts in context

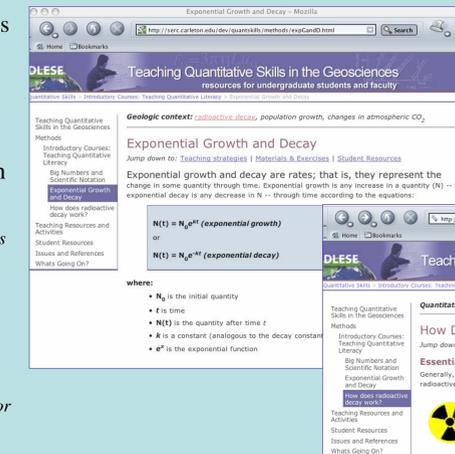


Finally, students learn quantitative concepts more effectively when faced with problems that have context to which they can relate. Geoscience disciplines can provide many examples of context.

The Website: Linking the “good ideas” to geoscience context

Methods: A methods section provides a variety of innovative ways to teach quantitative skills to geoscience students. These include strategies for teaching challenging quantitative skills in introductory courses and quantitatively-rich topics in upper-level courses such as:

- Modeling- *model representations and limitations*
- Problem based approaches - *links to JGE articles dealing with quantitative skills in context*
- Equations - *techniques for connecting mathematical and geological languages*
- Technology - *tutorials for computer software*
- Uncertainty - *significant figures, rounding, error propagation, precision and accuracy*



Within the Methods section, pages covering quantitative concepts are presented with teaching strategies for the “good ideas”. These mathematical concepts are linked to appropriate geologic context. Shown here are linked pages on exponential functions (quant. concept; left) and radioactive decay (context; below).

Teaching Resources and Activities:

A fully searchable database of teaching resources covering a

variety of quantitative skills in geoscience context can also be found on the website. These examples include learning goals, context for appropriate use, teaching notes and materials and other useful resources. All of the materials provide *more* than information about the activity; they are designed to help instructors teach linked mathematical and geological concepts creatively and effectively. Most of the materials are complete, downloadable and easily adapted to a number of courses offered in departments all over the country. The examples range from introductory material, such as exercises reinforcing basic quantitative skills, activities using real data and “back-of-the-envelope” calculations to upper level exercises for courses like Climatology or Geochemistry.

Student Resources: This part of the site provides links to sites written by the mathematics community on a variety of quantitative topics. Students can learn on their own at their own pace and explore the relationship of mathematics to their courses.

