Promoting Spatial and Temporal Visualization Literacy Among Introductory Earth Science Students

James D. Myers
Department of Geology and Geophysics
University of Wyoming
(magma@uwyo.edu)

As part of a Department of Education Fund for Improvement of Secondary Education (FIPSE) grant, I, along with my colleague Erin Campbell-Stone, am identifying those literacies (skills) students must master to be successful in introductory geology courses. In addition to subject content, we have identified six literacies that are important for students to master before they can successfully apply any scientific approach to a societal issue they may face later as citizens. For the Earth sciences, the technical literacies we have identified are:

- the power to interpret a *table, graph or chart*
- the facility to make qualitative assessments
- the capacity to perform simple *quantitative calculations*
- the skill to read different types of *maps*
- the ability to visualize in *three dimensions*
- the capacity to conceptualize *changes through time*.

Rather than identifying those students who lack these literacies and sending them to a campus resource center, e.g. math lab, reading center, etc, we are restructuring our introductory geology classes to incorporate these literacies into all activities associated with the class. By providing students with frequent and on-going practice with these literacies, we hope to foster their mastery by a much larger student population. To aid this development, labs, lecture activities, etc, will all contain a simple graphic that reminds students which literacies they are practicing while completing an activity.

Although one could argue that the first four literacies are common to all sciences, the last two, spatial and temporal visualization, are unique to the Earth sciences. Geology instructors ask students to visualize structures on scales beyond their everyday experience and which they have had little personal contact. In addition, these visualizations are constructed not from direct observation, but from indirect evidence acquired by a variety of techniques, some of which are quite complex. Armed with this information, students must construct mental models that can never to check authoritatively for accuracy, i.e. direct observation to compare interpretation and “real world”. This type of mental activity is clearly different from say biology where students draw cross-sections and diagrams of objects they have had personal experience with or can directly observe. Given the level of sophistication we are asking of students and the limited practice we provide them, it is not surprising that many students leave geology courses with only the most rudimentary spatial and temporal visualization skills.

With support from the FIPSE grant, we are restructuring our courses so students are given abundant practice with these skills. To accomplish this, we are pursuing a three-prong approach. First, we have constructed lab and lecture activities that require students to apply visualization skills to solve a geologic problem that occurs in the real world. For example in one lecture activity, students construct geologic cross-sections from drill cores to identify hidden igneous intrusions and determine which may be a potential ore body. Another lecture exercise has students find a displaced silver vein in the footwall of a normal fault. (Other lecture activities focus on correlation, groundwater movement, the rock cycle, and determining the plate tectonics of a distant planet.) Second, we are developing a catalog of Flash computer simulations and animations for teaching spatial and temporal visualization. We use these media in the lecture activities as well as labs and extra credit problems. Some files are 3-D blocks students can rotate in space whereas others are animations showing tectonic motions and activity solutions. Because these multimedia are delivered via the Web, they can be used in an instructor-directed mode, e.g. in class, or by students working independently. Third, we are building physical models of the “geologic structures” students model to provide them with a “real “ object on which to anchor their two-dimensional results, i.e. cross-sections, maps, block diagrams, etc. Small models are being constructed for use in the lab whereas larger models are being built for use in a large, auditorium-style classroom. To help students visualize the interior of these models, they are constructed of clear plexiglass so the interiors can be directly observed. Although more difficult to construct, this design does not require students to imagine how strata on the faces of the model project into the interior, an ability some students do not have. As our project progresses, we plan on posting object movies of these models on the Web along with streaming video clips illustrating their use.

My primary goal in attending the visualization workshop is to learn more about how students learn spatially and visually. We will use this knowledge to refine our models and improve their effectiveness. In addition, I would like to share our work with others to get feedback on what works on a cognitive level and what doesn't.