

Five concerns to address in geoscience education

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Geoscience is a latecomer to investigating how people learn in our discipline, in contrast to physics and chemistry, where the science of learning has been explored more fully. Perhaps this is because physics and chemistry were earlier faced with communicating very abstract concepts and laws that were not easily translated into words or pictures. Traditional geology has often been tarred and feathered as a “descriptive” subject, to distinguish it from the more “intellectually challenging” physical sciences, and most introductory and intermediate-level courses are very information-based. This has predetermined the teaching strategies that we have used, which have tended to rely on “show-and-tell” strategies that can work well for some topics. However, as our science deals with topics more involved than the identification of minerals, or the effects of glaciers upon the landscape, we need to ensure that our teaching strategies are up to the task. The complexities of climate modeling, mantle properties, and seismic interpretation demand that we investigate how students learn such concepts, so that our teaching strategies will be properly informed. Discussions around curriculum or courses are usually focused on the issue of content (what is to be included) rather than how we teach or why we choose that particular strategy. It is arguable that until recently the latter questions were not important, since learning any scientific subject seemed to involve the same procedures of reading, listening to lectures and perhaps reproducing experiments or investigations that formed the basis for the lectures and reading. However, as our knowledge base has grown, and as technology has altered the means that we can explore that knowledge, we need to step back and examine the whole process of learning geoscience.

The traditional image of science is usually given as “a white male in a lab coat performing experiments.” Geologists have (mercifully!) failed to fit this profile in almost all aspects, and this has been helpful in promoting geoscience to students who may not resonate with other science pursuits. The ability to leave the classroom behind for field trips and data-gathering expeditions can easily appeal to people who may not learn well in a lecture-lab format, and we should build upon this advantage. However, we really have yet to fully exploit this opportunity. When I first became acquainted with active learning and constructivism several years ago and I discussed these with geologist colleagues, the general reaction was: “Well, what’s so new about that? We have always taken our students into the field.” The act of leaving the classroom is conflated with the process of active learning itself, and perhaps this has stunted our interest in investigating why field trips can be so successful. We need to examine our current approaches to teaching geoscience and see how these address various ways of learning. Some aspects of the learning of physics or

chemistry are applicable to geology as well, but other aspects – such as perception in three dimensions and visual representations such as maps or cross-sections – may require some different methods for learning effectively. I see five general areas that our discipline needs to explore more fully:

1. Action Research and Learning Goals. One of the things we need to promote is action research on the learning and teaching in our classes. In other words, we need to raise the practice of teaching to a research project in its own right. Most of us, even at research universities, spend more time teaching than in pursuit of our individual investigations. In many cases, we have extensive documentation of student outcomes, our activities in the classroom, and summative evaluations that could form the basis of ongoing research in to the effectiveness of our instructional methods. Initiating appropriate professional development workshops around these issues can stimulate interest in a careful self-analysis of the methods we currently use and the effects they are having on our students. In a related effort, we need to have a realistic set of learning goals for students in the geosciences that are more than content goals. Individual instructors and some departments have dabbled in this endeavor, but there are more similarities than differences among the programs in various colleges and universities, so a set of goals could be established for the discipline as a whole.

2. Problem-Based Learning. Problem-based or case-study learning has become the norm for many medical schools and is now being used in some undergraduate biology courses. Since the geosciences have many practical aspects, several of which involving diagnosing and solving complex problems, a case-study approach may be a very effective learning tool. However, we have only a few models that have been tried. I can envision a library of case-based investigations centering on petroleum or mineral exploration, environmental contamination or remediation, and climate systems, that could be incorporated into undergraduate curricula. What research is currently available that shows the impact of case-study learning in those subject areas where it is widely practiced? Are these results transferable to geosciences? In what ways? An expanded effort in developing case-based learning in geosciences and in evaluating its impact upon student performance and development is an important goal.

3. The Role of Field Programs. Field experiences are a hallmark of geoscience instruction, and many programs require some field training for a degree. How effective are field trips and field courses in promoting student learning? My personal experiences are that many field trips are little more than lectures at the outcrop, despite the obvious availability of materials for on-site active learning. Extended field courses, whether during the summer or during the academic year, are usually more reliant on student initiative and discovery. What are the learning goals of field courses or programs that are distinct from traditional methods? Are these goals being achieved? What would it take to make field experiences a more successful learning strategy?

4. Using Technology Wisely. Technology can be both a blessing and a curse. Computer simulations can illustrate processes or concepts that otherwise must remain in our imaginations, and the analysis of complex sets of data can be streamlined to occur in a time frame suitable for classroom instruction. Computer networks provide opportunities for interactive homework that encourages active learning. Many institutions now support flexible web platforms, such as WebCT, e-college or Blackboard, which can simplify the task of incorporating web-based instruction into a course. What data are available on how these are being used? Classroom communication systems, such as Classtalk or CPS, can augment discussion and gauge students' understanding of concepts in real time. We have little first-hand experiences with these technologies in the geosciences, and we need to see how they are being used in other subjects. On the other hand, presentation software can limit spontaneity in the classroom, and may reinforce passive listening if used in a television-like entertainment mode. What are the most effective ways that technology can be used to enhance learning in the geosciences?

5. Assessment. Assessment is an issue that we have hardly examined, and it is arguably the most important of all. How can we be sure that the methods we are using are having the desired effects? Are the goals that we have established for our courses being met? Are the students learning at the levels that we want or expect? Many of us are wedded to the traditional exam as our principal assessment tool. How can we design exams that evaluate higher order thinking? Many other techniques have been put forward to assist with formative assessment: minute papers, portfolio assessments, longer projects etc. Are these effective methods? Are there reliable data on their use and proper application? We need to more fully integrate assessment into all the aspects of our teaching, so that we can be aware of the overall success of the methods we are using.

In summary, we are at, or even somewhat past, the point to evaluate some strongly held beliefs in geoscience education. The research that is being done on the nature of learning, on the various ways that different people learn most effectively, and on how individuals construct their understanding of science from preconceptions, can help us revitalize the teaching of our favorite subject. As good scientists, we should welcome the opportunity to turn our teaching into a part of our research program.