Teaching geoscience in a changing world

Rasoul Sorkhabi

Aside from astronomy, all natural sciences directly or indirectly deal with Earth, but one science that specifically studies Earth as a planetary system is geoscience or earth science. Geoscience encompasses a vast field, including geology, geochemistry, geophysics, oceanography and meteorology. Geoscience is an important science to society and should be a fundamental part of public and school education. For the developing countries endowed with natural resources as well as facing environmental challenges, natural hazards and resource mismanagement, geoscience education and research should be regarded as a high priority and vital to national security. Obviously the quality of geoscience education impacts research and development in the field. In a recent editorial in the pages of this journal, Dilip Saha[1] commented on how education also plays an important role in the employment of college graduates majoring in geoscience. Building upon his note, here I share some tips and suggestions for teaching geoscience courses. My emphasis here is on undergraduate courses, although many of the points highlighted below are also helpful for postgraduate courses in geoscience. The following notes stem from my years of teaching geoscience courses both at undergraduate and postgraduate levels. Nevertheless, this note does not claim to be inclusive of all principles and practices in geoscience education.

Advantages of geoscience

Geoscience has certain characteristics and advantages that should be utilized in the teaching. These points, outlined below, are valuable assets for the teachers to tap into.

(1) Planet Earth is an interesting subject. Even though most people think of science as dry and difficult, they are fascinated by gemstones, rocks, fossils, mountains, rivers, glaciers, seaside, clouds, and other geologic phenomena. People want to know how Earth functions, how the planet has evolved, and how minerals, rocks, mountains, oceans, etc. form. Indeed, a survey of science news stories reveals that discoveries related to geoscience are highly popular items for reading[2]. A geoscience teacher should utilize the student's curiosity about Earth as a valuable asset, and try to enrich and deepen it.

(2) Geoscience is an integrative science. It utilizes the principles and techniques of chemistry, physics, biology as well as mathematics to study various aspects of Earth. This means that geoscience education, to some degree, is also an education in science, and a geoscience teacher should be familiar with the other branches of science as well.

(3) Geoscience is an applied science. We study Earth in order to mitigate natural hazards, locate economic minerals and energy resources, help solve environmental problems, and construct safe buildings, bridges and dams. Geoscience education has thus direct economic and safety implications for society and human life.

(4) Geoscience is a regional science. It is intimately related to the landscape, tectonic setting, and natural resources of the cities and landscape where colleges are located. Geoscience teaching can thus be most effective if the teacher incorporates the local geology and environment in the lectures on various geologic processes and concepts[3].

The first class

The first class or the first week of the course is most important because first impressions cannot be gained the second time. I usually prepare very well for the first class and try to achieve four objectives. First, to explain why geoscience is important. Even though many students will pursue other careers after graduation (they all need not become geologists), learning about our home planet is useful and delightful for everyone. Second, what geoscience is; how it overlaps with and differs from other branches of science; how it functions and has evolved as a science; what are the main disciplines within geoscience (physical, historical, applied geology, geochemistry, geophysics, meteorology, oceanography). Third, what are the career paths for students majoring in geoscience. Finally, describing the course syllabus, study materials, examinations, and grading, as well as sharing my background and passion for the field both as a geologist and an instructor.

Balanced approaches

A keyword in successful geoscience education in colleges and universities is 'balance' – how to adopt a balanced approach to various components in geoscience teaching. These components may appear to be opposites and hence difficult to reconcile, but an experienced teacher creates harmony and synergy between them.

(1) Balance between textbook and new information. While college textbooks cover the basics and essentials of their subjects and disciplines, it is sometimes useful to share stories of new discoveries and breakthroughs with students. It usually takes several years for most significant discoveries to be discussed in textbooks. Fortunately, several magazines cover new discoveries and developments in science on a regular basis; these include *Science News* (USA), *Scientific American*, *Science* (USA), *New Scientist* (UK), *Nature* (UK), *Current Science* (India), *Resonance: A Journal of Science Education* (India) and *Science Reporter* (India).

(2) Balance between scientific information and science history. Sometimes we describe the concepts and findings of geoscience without explaining how they were actually discovered: how do we know what we know about Earth. Although a geoscience course is not one on the history of science, it is sometimes necessary to blend the textbook information with anecdotes from the history of science to show how geoscience works and grows. It is thus imperative that geoscience teachers also study the history of geoscience. Unfortunately, the history of science is not part of geoscience curriculum in our colleges and universities, and interested individuals need to rely on several books available on the history of geoscience[4]. Fundamental topics in geoscience such as uniformitarianism, evolution of life, age of the Earth, geologic

timescale and plate tectonics are better taught and learned using their historical contexts as well.

(3) Balance between plain language and technical jargon. A severe difficulty that most people face in studying geoscience is that the field is loaded with a large number of unfamiliar technical terms historically derived from Latin, Greek, German and French languages: augen gneiss, batholith, cephalopod, crystoblast, decollement, fenster, isostasy, klippe, ophiolite, phenocryst, serpentinite, Triassic, xenolith, and so forth. The geoscience teacher is thus faced with the dilemma of how to describe the processes, materials and structure of Earth in plain language without overloading the student's mind with strange jargon. Of course, the essential terms need to be used, and students learn them best if the etymology and meanings of these terms are first explained; for example, how the different stratigraphic periods (Cambrian, Permian, Cretaceous, etc.) were named. Or sometimes, we can substitute more familiar words; for example, 'left-lateral' for 'sinistral' fault; 'mountain-building' for 'orogenic' events; 'failed rift valley' for 'aulacogen', and so forth. Too much focus on unfamiliar technical jargon can discourage the students and should be avoided in introductory geoscience courses. Perhaps an analogy helps here. An automobile has hundreds of parts and a car mechanic is expected to know their names and functionality, but an ordinary person only needs a minimum knowledge of car mechanics in order to drive safely. Similarly, a professional geologist is required to have an extensive knowledge of geologic jargon, but a non-major student need not. A process-based geoscience education with a reasonable amount of terminology is more suitable and effective in introductory courses.

(4) Balance among descriptive, graphic, practical and mathematical presentations. Students learn differently. Some learn better through words and abstract concepts; some prefer images and diagrams; some learn most from hands-on experiences, and others are more comfortable with numbers and equations. Various methods should thus be employed in teaching: lectures, documentary films, field trips, in-class activities, examining mineral, rock and fossil specimens, report writing, quizzes, calculations, etc. appeal to different aspects of learning.

Here I should add a note on the relationship between geoscience and mathematics. Geoscience is often perceived as a descriptive science, as if mathematics has no place in it. It is important to expose the students to simple calculations and equations related to geoscience. For instance, I often ask students to calculate the circumference, area, volume and mass of Earth; calculate the vertical offset (throw) and horizontal offset (heave) of a fault or the true thickness of an inclined or eroded sedimentary layer using simple geometry and trigonometry. Recall that the ancient Greek science of 'geometry' literally meant 'earth-measurement'.

(5) Balance between theoretical and practical learning. Conceptual knowledge has its own significance but geoscience education should not be limited to bookish information. Indeed geoscience is about the outdoors. Students should be encouraged to learn through observation and practice: visiting outcrops, natural history museums or national parks, examining minerals, rocks and fossils, drawing graphs and maps; photography, using Google Earth and GIS for mapping, etc. should be part of the geoscience education. In this way, students are better prepared to use technological and digital tools in studies and projects. Let us remember this famous quote by the British geologist Herbert Harold Read: 'The best geologist is he (or she) who has seen most rocks'.

(6) Balance between hard science and fun learning. Teachers are educators not entertainers; nevertheless, teaching is an art. Science in general can be hard and dry for many people. Students learn better when teachers introduce audio-visual materials, interactive (question and answer) time as well as some wit and humour into their lectures and classes.

Our science, technology, planet and society are all changing; so should geoscience education to address the new progress, problems and prospects. Gone are the days when a teacher would teach the same lessons from a single textbook for many years. Digital information technologies are rapidly altering the way people live, work, think and communicate around the world; these technologies need to be incorporated in geoscience education. The *Journal of Geoscience Education* published by the US National Association of Geoscience Teachers offers many informative case studies for improving our teaching and learning of geoscience courses.

Many students take a geoscience course as part of their science graduation requirements and will probably never take another such course in their lives. Some students, on the other hand, may decide to major in geoscience. In either case, a successful course in geoscience plays an important role in the learning and careers of college students. And classroom is a valuable opportunity for a geoscience teacher to share his/her profession and passion with society.

1. Saha, D., *Curr. Sci.*, 2018, **115**(4), 595–596.
2. Sorkhabi, R., *Curr. Sci.*, 2018, **115**(7), 1245–1246.
3. Sorkhabi, R., *J. Geol. Soc. India*, 1997, **49**(5), 604–606.
4. There are several introductory books on the history of geoscience: Faul, H. and Faul, C., *It Began with a Stone: A History of Geology from the Stone Age to the Age of Plate Tectonics* (Wiley, New York, 1983, p. 288); *A History of Geology* by Gabriel Gohau (Rutgers University Press, New York, 1990, p. 259); *A Brief History of Geology* by Kieran D. O'Hara (Cambridge University Press, Cambridge, 2018, p. 264).

Rasoul Sorkhabi is in the Energy & Geoscience Institute, University of Utah, Salt Lake City, UT 84108, USA.
e-mail: rsorkhabi@egi.utah.edu