Teaching Geoscience Methods in the Field

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Learning in the field has traditionally been one of the fundamental components of the

geoscience curriculum. There are many attributes of learning in the field environment that address teaching GeoMethods: definition of learning goals related to mastery of geoscience concepts and content; the development of professional skill sets that are used to describe, characterize, measure, and interpret data acquired directly from natural environments; leveraging the affective, cognitive and metacognitive gains afforded to students through learning in the field; and engagement by students in the community of practice that has been developed and accepted by geoscientists as a result of field studies. An awareness of these attributes will contribute to the design, development and implementation of effective instruction in the field. The following is a summary of a more comprehensive review of learning in the field by Mogk and Goodwin (2012) as part of the Synthesis of Research on Learning in the Geosciences project. Additional insights into teaching and learning in the field can be found in Whitmeyer et al., (2009).

Teaching GeoMethods in a field setting must be done in consideration of many factors. First, learning in the field is meant to encompass a range of activities that are physically conducted in the natural environment: making primary observations of Nature; taking samples; making measurements; directly using the human senses; and indirectly using instrumental sensors to interact with Earth objects and processes. The Earth system is inherently complex, dynamic, heterogeneous, and often chaotic, and presents many challenges to geoscience education. Frodeman (1995) has emphasized the historical and interpretive aspects of geoscience (as opposed to bench top, experimental science mostly done in highly constrained, closed systems). The geologic record is often incomplete or ambiguous, and consequently, the nature of geoscience expertise requires the development of cognitive strategies that allow geoscientists to work effectively in a world in which the available evidence is complex, uncertain, and often missing.

It is also important to consider the scope of field instruction that may range from a two-hour laboratory exercise in a location proximal to the classroom to sustained residential field camps with a duration of weeks to months. Field activities may be immersive or reconnaissance in nature, require geologic mapping on many scales, may focus on sampling activities, perhaps focus on measurements of geologic phenomena (stratigraphic sections, stream gauging), and increasingly use instrumentation (field geophysical surveys) or computer-based technologies (“GeoPads”) in the conduct of field work.

Considerations for teaching GeoMethods related to field instruction include:

* Students experience direct contact with the raw materials of Nature in their full complexity, while in the lab, samples are presented without the full context of their natural setting; and, the rational for collecting particular samples may be lost;
* In the field, the scale of observation is large with respect to the observer and thus perception is from an internal spatial viewpoint, whereas in the lab the student observer is large compared with lab samples;
* Physical movement through the field setting engages all of the senses which are strongly coupled with cognition and access by long term memory for future retrieval and use;
* Field work provides unique perspectives of the world, particularly related to spatial and temporal relations, that cannot be reproduced in laboratory or virtual environments;
* The field setting is a particularly rich environment where students have to make their own informed decisions about what to observe, for what purpose, how to represent these observations and how to interpret and ascribe meaning to their work.
* A trained eye must be developed to know what to look for in complex natural landscapes, as much of the sensory input may be irrelevant to the task at hand; in the lab setting, the objects of study have been selected by someone else and are specifically relevant to the topic of study;
* The field setting has a strong affective component that impacts learning. In some cases, there is a strong motivation to learn based on curiosity, awe and wonder; in other cases there may be significant barriers to learning that derive from fear or uncertainty. The affective domain also extends to interpersonal relations, and strong affiliative ties may develop between students, their peers, and mentors. Managed appropriately, students can gain an enhanced sense of self-confidence and self-reliance.
* The field setting also has a very strong metacognitive component. Field instruction can help students become self-aware of their approach to a given field task, to self-monitor their progress, and self-regulate their actions and make informed decisions as they confront emerging problems, unexpected findings or inconsistencies.

Cognitive, learning and social sciences provide additional insights into the value of field instruction, and why this is so important to teaching GeoMethods:

* The full range of cognitive skills (e.g. Bloom’s taxonomy) are engaged in field studies from primary observations and descriptions to higher order thinking sills that emphasize inquiry, discovery, analytical and synthetic reasoning, critical-thinking, and problem solving skills. This also includes the ability to deal with ambiguous, uncertain and incomplete data, and the ability to make internally consistent interpretations (or inferences) based on these data.
* Learning in the field is both integrative and iterative. To be able to interpret natural phenomena, students must be able to bring to bear concepts and knowledge from the breadth of their academic training; in turn, observations in the field may serve to inform students about new tests or lines of reasoning.
* Embodiment—students work in both a natural and a social setting while doing field work. Body and mind are intimately connected and the physical movement through natural environments is critical to cognition and long-term memory. Similarly, field work is often done in field parties, and embodied knowledge is imparted to co-workers through gesture and demonstration. This is an essential component of teaching GeoMethods: demonstrating to novices how to navigate through physical space, and how to interact with the objects of study.
* Inscriptions—are representations of natural phenomena such as maps, graphs, and other sketches and visualizations that serve to explain, confirm, rationalize and externalize our understanding of Earth. It is the first inscription, where we translate Nature into culture, that is the most important because it is this cognitive step that defines what is important and what is to be excluded in relating outcomes of our studies. There are also “chains of inscriptions” that become increasingly specific in their ability to represent information (but also become increasingly exclusive and removed from the natural state; e.g. geologic map, to cross section, to stereonet, to thin section….). The importance of inscriptions to teaching GeoMethods is that they become permanent, portable, and public records of our understanding of Earth. This is how we “tell the story of Earth”.
* Community of practice—The field setting is where students learn FROM Nature and ABOUT science as a social enterprise. The community of practice in the geosciences includes: language translated into practice; the selection and appropriate use of tools to acquire, organize and advance community knowledge; shared ethics and values; and collective understanding of questions, methods, strategies, and their limits and uncertainties. Field instruction also leads to the development of important personal and professional social networks through shared experiences at field camps and field conferences and the norms and expectations of personal and communal conduct.

Some implications that inform how we teach GeoMethods in the field include:

* Field instruction must be student centered, and include emphasis on content and skill mastery, with attention to affective aspects, and intellectually and emotionally challenging at appropriate levels (e.g. Vygotsky’s “zone of proximal development”).
* Field instruction must be purposeful and well integrated with the rest o the geoscience curriculum. Students must be intellectually well-prepared to optimize learning in the field, and have “fertile minds” that are ready to internalize, organize, prioritize, and utilize the complex relations observed in the field.
* Learning goals for field instruction must be clearly articulated as appropriate to the level of preparation of the students. Learning goals may range from demonstrations of mastery of concepts or skills to a simple appreciation of the wonder of Nature as a possible motivator of learning (and recruitment to the discipline).
* Assessments of learning must be well-aligned with the learning goals. Formative assessments are particularly important, as students may readily get lost (physically and intellectually) in the complexity of the natural environment.
* Practical aspects of teaching GeoMethods include the need for careful planning by the instructors to insure a good and productive field experience. And recognize that going out into the field does not necessarily mean that students will learn.

Finally, I’d like to emphasize that learning in the field affords types of learning that cannot be achieved as easily or at all in other more controlled learning environments. The field setting evokes a very strong affective response that is strongly connected to cognitive functions. The learning of science is best done in the doing of science, and this is well-realized in the embodied practice of field work in both natural and social settings, and through the creation of inscriptions to represent natural phenomena. I would affirm that learning in the field is an essential component of professional training for ALL geoscientists, regardless of the sub-discipline of interest. It is in the field setting that the full history of Earth, its processes and products, over a range of temporal and spatial scales, are fully realized. It takes a long apprenticeship for novice geoscientists to be fully inculcated into the community of practice, so my advice is to get out into Nature early and often.

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