Analogical Thinking in Geoscience Education, Jee et al., 2010

Abstract:
Geoscience instructors and textbooks rely on analogy for teaching students a wide range of content, from the most basic concepts to highly complicated systems. The goal of this paper is to connect educational and cognitive science research on analogical thinking with issues of geoscience instruction. Analogies convey that the same basic relationships hold in two different examples. In cognitive science, analogical comparison is understood as the process by which a person processes an analogy. We use a cognitive framework for analogy to discuss what makes an effective analogy, the various forms of analogical comparison used in instruction, and the ways that analogical thinking can be supported. Challenges and limitations in using analogy are also discussed, along with suggestions about how these limitations can be addressed to better guide instruction. We end with recommendations about the use of analogy for instruction, and for future research on analogy as it relates to geoscience learning.

Extended abstract:
Geoscience instructors and textbooks rely on analogy for teaching students a wide range of content, from the most basic concepts to highly complicated systems. The goal of this paper is to connect educational and cognitive science research on analogical thinking with issues of geoscience instruction. Analogies convey that the same basic relationships hold in two different examples. In cognitive science, *analogical comparison* is understood as the process by which a person processes an analogy. In some cases the goal is to use an existing familiar source example to provide insight about a less familiar or more challenging target example. This kind of analogy is called *projective analogy*. Effective projective analogies for novice students tend to involve examples for which: (1) the correct knowledge is readily retrieved and (2) corresponding elements in the source and target are relatively easy to align; and (3) the two examples are sufficiently different that the common system stands out (always provided that condition (2) is met). A further desideratum for projective analogies is that a number of useful inferences are possible.

There is another important kind of analogy, in which the source and the target are both only partially understood. In these analogies, referred to as *mutual alignment analogies*, the two analogs are typically both from the same domain or topic and are similar enough to be easily alignable. In mutual alignment analogies, the chief goal is precisely for the student to notice and abstract the common system. An important benefit of mutual alignment is that it renders the common system more salient to the student. Another use of mutual alignment is for contrast. Once the two examples are aligned, differences connected to the common system stand out. By comparing examples from different categories, a student can learn the properties that distinguish members of the two categories. When two contrasting examples are highly similar, differences between them become more salient. For example, the concept of a *fault* - and how it differs from a fracture – can be clarified by comparing

an aligned pair of examples that are alike in every way except that in one case there is a simple fracture and in the other a fault (that is, slippage along the fracture), as in Figure 1.

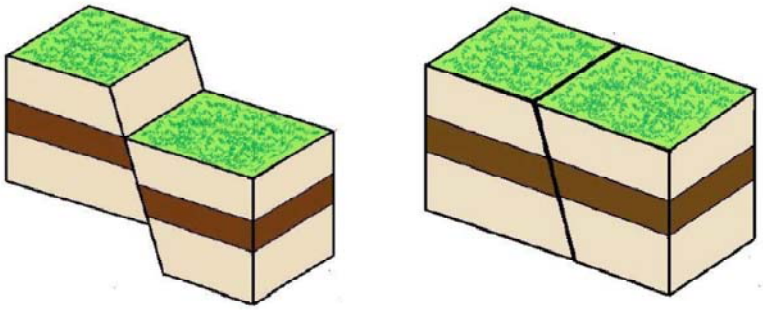

Figure 1. Highly similar contrasting images depicting a fault (left) and a fracture without a fault (right).

Besides using good analogies and avoiding ineffective ones, instructors can greatly influence how much students learn through the process of analogical comparison. Instructors can support students‘ analogical thinking and learning by (1) ensuring that students explicitly map the structure of the analogy, (2) confronting erroneous inferences before they take hold, (3) keeping the examples available as the student processes the analogy, (4) increasing the surface similarity between the examples to facilitate the alignment of corresponding elements, and (5) highlighting a key distinction between two examples by aligning two examples that are identical except for that distinction. By considering the roles of analogies, including those that use physical models, we can expand our use of analogy, make explicit to students the role that analogies are playing in their learning, and help them develop general expertise on the use of analogy to learn.

Analogies are such a fundamental part of geoscience teaching that additional work in this area would likely yield substantial benefits. It is our belief that further collaborations between cognitive scientists and geoscience instructors will pave the way to new insights about analogical thinking in this complex, challenging domain, and contribute further enhancements to geoscience instruction.