Learners' Intuitions about Geology

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Abstract: Many principles in geology are intuitive to geologists who already understand those principles, but little is known about learners' intuitions in geology. We apply existing theoretical machinery about learners' intuitions in physics to learners' intuitions in geology, and we present several examples of geology intuitions from teachers' reasoning about relative age relationships during field instruction. Implications are discussed for how to productively harness learners' intuitions in geoscience education.

Learners' Intuitions from Physics Applied to Geology

In the learning sciences, there is a body of work investigating learners' productive use of intuitions in various STEM fields. Pratt and Noss (2002) presented a model of the microevolution of mathematical knowledge that included what they called naïve resources about randomness. Talmy (1988) focused on what he called "force dynamics" which are patterns and linguistic expressions for physical causes.

diSessa (1993) outlined a framework for learning physics that is based on students having a collection of intuitive knowledge about the physical world. These knowledge pieces, known as phenomenological primitives, *p-prims*, are thought to be the fundamental elements of the cognitive system. They are important for thinking and learning in physics. They are intuitions that can be accessed in both everyday life and the physics classroom. An example of one of these intuitions is *Ohm's p-prim;* more effort begets more results and more resistance gets less results. This is often simplified to "more is more". This intuition can be applied to many situations. For instance, to explain why one needs to push harder to move heavier objects, one cites more weight and more resistance, which implies more force is needed. Researchers have expanded this work to identify p-prim type intuitions in other STEM areas. For example, Lewis (2012) identified intuitions relevant to programming in computer science. Through a larger project investigating teacher's learning about topics in bedrock geology we are beginning to identify geology intuitions that may function similar to p-prims observed in physics. Extending work in physics education to geology education is reasonable because we would expect intuitions about the physical world to cross discipline boundaries.

Many fundamental principles in geology, such as the principle of original horizontality, which states that layers of sediment are deposited in horizontal layers due to gravity, are thought to be intuitive among geologists. This is not surprising as geology developed as an interpretative science from scientists carefully observing the natural world, intuiting how features arose. As observations of the natural world hold a prominent role in geology, learning in field environments has been key in geology curricula. Recently, Mogk and Goodwin (2012) reviewed the goals and attributes of field instruction and discussed gains from field instruction in terms of embodiment, creation and use of inscriptions, and initiation into communities of practices. They described the arc of field instruction as new geologists learn the practices of experts.

Here we connect intuitions about geological principles to research on intuitions in physics. We argue that in some cases learners use these principles in ways similar to how p-prims are used when learning physics. We illustrate this argument with excerpts from data of teachers discussing the bedrock geology and glacial geology of the area.

Data Collection and Methodology to Identify Intuitions

The data were collected as part of a professional development workshop with 17 sixth-grade earth-science teachers. The goal of the workshop was to support teachers in becoming accustomed to modeling as described in the Framework for K-12 Science Education (NRC, 2012). The content focus was the geological history of the Schoodic Peninsula in Acadia National Park. During the workshop, teachers were engaged in fieldwork where they made a series of observations, drew surface and cross-sectional maps of the bedrock and surface features at three different locations while learning about important geological principles. Using these data, the teachers developed a series of increasingly sophisticated models of the geological history at three points in time (400 million years ago, 200 million years ago, and 20,000 years ago). Data consisted of video and audio recordings, drawings created by the teachers, and researchers' field notes. Initially we open coded the data. From these open codes we developed a set of focused codes including intuitive ideas relevant to geological principles.

As described in diSessa (1993) p-prims are easily recognized and self-explanatory. When someone uses a p-prim to reason no further explanation is needed, there is a "that's how things are" implication. When identifying p-prim-type intuitions it becomes important to look for instances where learners were satisfied and confident with their reasoning. Another way to identify p-prims is to look for cases where people use everyday language. Finally, a useful heuristic is to look for commonalities across individuals or contexts to triangulate the p-prim across situations. These heuristics were applied to the current data corpus in conjunction with the existing list of p-prims (diSessa, 1993) to identify a series of candidate intuitions that are potentially p-prim-like.

Data Analysis and Results

Sample data and results are presented in Table 1, and additional intuitions and data will be presented in the poster. Some of the geology intuitions listed are likely combinations of multiple p-prims-like pieces. This is not surprising given different intuitions often have a high likelihood of occurring in tandem (diSessa, 1993).

Table 1. Example intuitions in geology

Intuition Name	**Theoretical Schematization of the Intuition**	**Proposed Idealized Geology Example**	**Data Excerpt**
Conformity of Shape	A liquid takes the shape of a solid that is encasing it; the surrounding substance guides a flowing substance. Possibly an application of vacuum impels, which is schematized as emptiness requires filling (diSessa, 1993, p. 219).	As a hot liquid rock cools it takes the shape of a solid rock surrounding it resulting in the cooling rock's shape conforming to the surrounding rock's shape.	Teacher: It just makes sense to me that this other one came up and filled in the cracks... you can see what's holding this, I guess, it looks like it flowed, you know what I mean, flowed in that crack,...it seems like the black [rock] flowed around because when you look at the stripes going up, this one here it looks like it filled in a crack that was already in the granite.
Heavy things move downhill	Heavy things under large amounts of pressure will flow downhill.	A glacier feeling the effects of its own weight will flow downhill or down a path where there is least resistance.	Instructor: What causes the ice to flow? Why does it want to flow in the first place? Teacher: Cause, the weight of it pushing down on it, it's more fluid than solid…weight of it pushing down, it melts stuff at the bottom and goes where it can.
Springiness and rebounding	An object gives under pressure and then rebounds when the pressure is released. Possibly related to springiness and spring scale p-prims (diSessa, 1993).	Glaciers are heavy and will push down on the rocks, resulting in the compression of the bedrock below. When the glacier retreats the rocks will rebound.	Teacher: When the glaciers were here, it pushed the land down, and then when the glaciers melt the land comes back up, so maybe the cracks were formed that way. Instructor: So the pressure that came off when the glaciers went away. Alright. Teacher: I wonder if we are still rebounding, are we still rebounding from that glacier?

Conclusion and Discussion

Learners accessed intuitions during geology field instruction that shared some resemblance with existing intuitions that are known to influence reasoning in physics. While this is not surprising because of the close theoretical relationship between geology and physics, it might be productive for education research and instruction in geology and other interpretative sciences to take into account learners' intuitions.

References

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