Embracing the "Mess" in Environmental Systems

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Geological problems such as those commonly found in the fields of environmental engineering and the geosciences are uniquely suited to an interdisciplinary approach. The environment itself is a highly complex system which consists of influences over wide spatial and temporal scales, which allows for the integration of many different ideas and concepts. The wide scope of environmental issues allows us to draw connections between many systems which at first glance would seem to be disparate; to embrace the "mess" of environmental systems.

Interdisciplinary Examples from Real Experience

Although the fields of environmental engineering and environmental science tend to ask different questions, they are two sides of the same coin. Environmental engineering is normally associated with the design and building of practical solutions to a problem, where environmental science aims to answer questions about why or how certain geological processes occur. In this way, the two fields can provide differing insights on the same issue. For example, say in an Oceanography class we begin to talk about the factors that create a tropical cyclone, and a student asks about Hurricane Sandy. The students can now learn about the mechanism behind the formation of tropical cyclones, as well as the engineering solutions designed to help cities cope with the destructive effects of such a hurricane. In turn, these topics can be related across disciplines to the economic losses from the storm, and even the lasting social effects which a storm has on a populace not acclimated to such a phenomenon. Providing such depth in specific examples is important to show the far reaching effects of systematic changes, and highlight the importance of the concepts involved. These real life examples bring relevance to the topics being studied, and also may garner more interest than only teaching conceptual hurricane formation dynamics without application.

Environmental Concepts & Mental Schemata

The experience of grappling with processes across large swaths of space and time can be a tough exercise for some students at the beginning of their education, but this can be made easier by the aforementioned cross-discipline examples. From a psychological standpoint, providing such an example allows for the formation of an organizational mental framework (commonly called a schema) under which to interpret other similar phenomena and allow for quicker categorization (Kastens, et al. 2006). For example, the principal of superposition, once learned can provide a framework for interpreting the age of fossil-bearing strata. When confronted with possible conflicting evidence from, for example a thrust fault where older layers seem to have been laid above those younger, this provides the opportunity for another framework to understand the new geophysical processes, or for further information to be added to the old schema to incorporate the new observation. Similarly, laboratory or field exercises are important as they add a hands-on experiential component to the schema formation; adding personal memories to solidify the applications of the concept. In the same way, thinking of sustainability in this context intrinsically adds a temporal component to such an example, asking "what will happen in the future; can this system endure?" These techniques of expansion of an idea over time and space are skills which are used by geoscientists and environmental engineers alike to make predictions, and in this way the "mess" in the environment can be thought of in terms of a small slice of a changing system through time and space.

Grappling With Real Data, Together

At the same time, just providing examples of a problem and a framework to refer to isn't always enough to teach the concepts at hand. For example, when teaching about air filtration methods for an environmental health and safety course, we talked about using a filter with a known flow rate of air past the filter, and being able to from there find the average concentration of a known mass of substance on the filter. However, these students clearly didn't really understand the concept until they had gone through the calculation and subsequent dimensional analysis, and actually collected dust with the filter. Dealing with the real environmental data provides practical skills which students need to know in the workforce and in graduate school, while bringing clarity to the possibly vague concepts discussed in class. This also explicitly outlines the "how" of drawing conclusions from a set of data, and allows for any confusion about the topics to be worked out by the student. For example, for a sedimentology course, the professor used a "do-talk-do" method of learning. The students would work with real data or modeling software, talk to each other about what they found and any problems they may have encountered, and then return to the data to draw conclusions and insights again, using the information they received from their classmates. The increased level of complexity and often large magnitude of data points provided to the students required the use of many of the basic science and math skills in drawing conclusions from the data, as students can be heard asking "what does this trend mean, though?" as they work through the tough task together. The connection to other previously learned concepts will make the new concepts learning easier to understand and more permanently learned. Also, this "data grappling" can outline problems and suggest solutions in a more accessible way than some conceptual models do.

Dealing with real environmental problems using actual datasets and examples is important as this is what students will have to do both in an environmental field, and doing so provides them valuable skills for their future. This also provides a framework for interpretation of wide-spanning, complex ideas while bolstering the structure with real life, relatable examples and data that the student can draw on as archetypical schema in the future. In general, the method of taking a conceptual model of a mechanism or problem to be solved and bringing it down to detailed examples across disciplines with real data that outlines those examples would enhance geological science and engineering education. Finally, providing ample space in the curriculum for inter-student collaboration builds upon the previous techniques to allow for even greater learning to occur.

Kastens, Kim A., and Toru Ishikawa. "Spatial thinking in the geosciences and cognitive sciences: A cross-disciplinary look at the intersection of the two fields." *SPECIAL PAPERS-GEOLOGICAL SOCIETY OF AMERICA* 413 (2006): 53-76.