Learners as researchers: teaching concepts of stability and change in natural systems through project-based exploration of paleontology

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Engaging Questions: where, when, why, how?

We framed the course with the questions: when? where? why? and how? This structure showed how the intersections between stratigraphy, geochronology, climatology, and evolutionary biology allow paleontologists to describe a fossil organism. These questions were revisited often as teachers connected their understanding of concepts with enactment of activities. To approach the question of “when?” for example, we made a paper geologic timescale, and used it with frequency as a backbone for the concepts of phylogenetics, extinction, and plate tectonics. Teachers emphasized the value of activities such as the paper timescale, saying that it helped them understand the scale of Earth history. They also felt the timeline allowed them to conceptualize how incrementally slow or intermittent processes (e.g. natural selection; tectonic plate movement) have wrought immense changes and biotic diversity observed in the present day.

We structured the course around the “5-E” learning cycle model. Students begin the project by engaging with material, for example by listing what they already know about the subject. Then students explore the subject by asking questions, and use their research to explain the answers to those questions. In the extension phase of the project, students look beyond the immediate subject, making links to other parts of life or other fields. In our class, these links were often to human impacts on earth systems, climate change, and, since the students were all science teachers, science education. The self-evaluation part of the cycle is extremely valuable, allowing students and instructors to reflect on the outcomes of their work and cement what they have learned.

Exploration: independent & group research projects

Above right: a student records the results of a coring simulation that used play dough (ice layers) and bubble tea straws. We did this activity right before going to the Hall of Planet Earth in the American Museum of Natural History, where they could see an actual ice core. Students reported having a better grasp of this concept thanks to the hands-on activity before entering the museum.

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Self-Evaluation, Learning Outcomes

The final project was to interpret the findings of an actual paleontology journal article or articles, and present the information to the rest of the class in plain English terms. Students’ presentations were recorded and shared, so they could refer to them in writing the post-course reflection.

Reflections emphasized the value of being placed in the position of student for developing empathy. Many also wrote that the hands-on explorations were critical in their understanding of an idea, eg. with the ice cores.

Next Generation Science Standards: Cross-Cutting Concepts

A Cross Cutting Concept in the K12 Next Generation Science Standards is stability and change in natural systems. Paleontology provides opportunity to examine stability and change: the study of evolutionary rates; processes of fossilization and the rock cycle, and patterns of extinction rates and mass extinctions. In a 4 week course for K12 teachers we explored this concept in a variety of ways: observing rocks in the field, simulating evolutionary processes, examining specimens, and using techniques to record change over time in these systems.

Videos of final presentations, shared online with the class.

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Year 1:
Neuroscience and CMT Disease
Body Systems (Nervous System)
Cells and Cell Systems
DNA, RNA, and Proteins

CCCs:
Structure and Function, Macro to Micro, Systems

Year 2: Paleontology and Extinct Mammals from South America
Earth History, Facies and Habitats
Evolutionary Relationships and Processes

CCCs:
Structure & Function, Systems, Stability & Change

Year 3:
Ecology and Benthic Organisms of the Long Island Sound
Biodiversity, water quality, adaptation, interdependence, human influence

CCCs:
Systems, Energy & Matter, Stability & Change

Explore
Engage
Evaluate
Extend
Explain

5-E cycle