Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2008 Volume V: Forces of Nature: Using Earth and Planetary Science for Teaching Physical Science

Introduction

One of the problems of teaching physical science is the need to cover fundamental concepts, tools and language before getting into applications. But scientific concepts without applications can be disengaging. Therefore, the aim of this seminar was to explore ways of teaching concepts and real-world applications at the same time; we considered examples – and demonstrations – at the same time that concepts were presented. This seminar was intended for professional educators from the full range of grade levels. Fellows' proposed curriculum units helped to shape the ultimate areas of focus in the seminar, which included some mathematics.

Below is a list of major physical science fields, with physics themes to use and corresponding possible examples.

Forces, movement, gravity

· Physics themes to use: movement, velocity, acceleration; forces including gravity, friction, elastic response (springs).
· Examples: Falling meteorites, landslides (gravity and friction), earthquake mechanism (friction and elasticity), earthquake waves (elastic waves).

Energy and power

· Physics themes to use: work, kinetic energy, potential (stored) energy, sensible heat, latent heat (changes in phase); nuclear energy.
· Examples: Energy in the origin of the solar system (gravitational collapse), fusion inside stars and making the elements. Energy in collisions of planets/asteroids. Heat release from inside planets. Solar heating and surface energy cycles (water, greenhouse effect, photosynthesis). Energy released in earthquakes. Power source for hurricanes (vaporization and condensation of water).

Fluid flow

· Physics themes to use: States of matter (gas, liquid, solid) vs. how things deform (fluid, elastic, plastic). Pressure and pressure differences (which makes fluids move). Viscosity. Buoyancy and convection.
· Examples: Flow of rivers; floods. Slow, viscous flow such as glaciers. High pressure and low pressure zones and winds. Waves in the ocean; tsunami. Convection inside the Earth (mantle and core), in the atmosphere (winds) and oceans (gulf stream), and stars (solar granulation).

Effects of rotation

· Physics themes to use: Rotating frames. Angular motion (angular velocity, momentum and the "ice skater" effect). Centrifugal and centripetal "forces." The Coriolis effect.
· Examples: Orbits of planets. The Moon and Earth. Tides: ocean tides and solid tides of Jovian/Galilean satellites. The spin and shape of planets and stars. Coriolis effect and atmospheric circulation (prevailing winds) and giant storms (hurricanes, Nor'easters).

Electricity and magnetism

· Physics themes to use: Electrical charges and electric fields. Magnetic substances and magnetization. Electrical currents and magnetic fields. Moving charges (or electrical conductors) in a magnetic field and electromotive force.
· Examples: Thunderstorm electrification (charge build-up) and lightning. Earth's magnetic field. Electrical motors and generators ("dynamos") and the cause for the magnetic fields of Earth, some planets and the Sun. Solar wind, magnetic storms and aurora borealis and australis.

Each Fellow in the end chose from some section of these themes and applied it to his or her particular subject and class needs. The eight units ranged from subjects geared toward teaching math to upper-level high-school students, to teaching basic early elementary-school subjects or in dual-language settings. Two units used either waves (sound and seismic waves for one, or the many types of ocean waves in the other) for teaching high-school algebra, geometry and calculus. Another unit discussed gravity and planetary motion and tides for teaching high-school geometry as well. Five of the units were geared toward elementary-school students. Two units focused on properties of matter to explain how things break or move in nature; for example why failure of rocks leads to earthquakes or landslides, or changes in states of matter (such as gas to liquid) are important for powering hurricanes and storms. Another unit focused on using the solar system and planets to teach students about length and time (e.g., the relative sizes and distances between planets, or the length of days and years on other planets), while in a dual-language (Spanish and English) environment. Another unit

used volcanoes to teach students about the inside of the Earth, plate tectonics as well as geography and history. Finally, one unit used convection in the Earth's atmosphere to explain climate and food production in Ghana.

Together the units represent a full spectrum of applying natural science to teaching basic concepts, in contrast to teaching basic concepts first and then using natural examples to illustrate the concepts.

David Bercovici