Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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# Introduction

Many recent initiatives seek to improve math and science education in the U.S. Efforts generally involve increased emphasis on, and new teaching methods in, basic math and science topics. We would all benefit from a better-educated, highly innovative populace, but how do we get there? How might improvements to math and science education be optimized so as to improve student proficiency now, and work force capability later?

In this seminar, we explored the integration of engineering concepts into existing K-12 curricula. Examples – theoretical and lab-based – were presented from Chemical, Civil, Electrical, and Mechanical Engineering, and their potential curricular insertion examined. Engineering Design was interspersed throughout, and served to conceptually link math/science skills, engineering principles, and innovation.

The seminar began with introductions to the history of engineering, to simple early machines such as the lever, and to the elements of engineering design. Subsequently, specific engineered systems were examined, including bridges, polymers, photovoltaic cells, electronic circuits, and trebuchets. Finally, a comprehensive treatment of engineering design – including economic analysis – was undertaken.

Participating Fellows gained knowledge of engineering fundamentals, applications, and career opportunities. In parallel, Fellows completed curriculum units seeking to integrate engineering concepts into their K-12 teaching.

Karen Beitler's unit focuses on polymers and nanotechnology. Students learn of the basic building blocks of polymers, the nature of the polymers encountered in everyday life, new technologies employing polymers at the nanoscale, and challenges and opportunities of recycling polymer materials. Polymers continue to change the way we live, and nanotechnology promises to accelerate the pace of change. By addressing key scientific, technological, and environmental underpinnings, Beitler provides balanced insight into these amazing materials.

Carol Boynton's unit focuses on simple machines: the lever, wheel, pulley, inclined plane, wedge, and screw. Through these machines – ubiquitous but often unnoticed in everyday life –she develops important engineering concepts such as work and mechanical advantage. Through children's literature, classroom exploration, and experimentation, students learn how simple machines work and benefit mankind, and gain a life lesson into what it really means to "work smarter, not harder."

William McKinney introduces a medieval siege weapon – the catapult – as an innovative tool to teach quadratic functions. Teams of students launch projectiles with a real model catapult, experiment with various settings (arm length, release angle, rubber band extension), record and graph the resultant trajectories, and employ regression techniques to obtain best-fit parabolas. Mathematics commonly precedes engineering, as a tool toward its understanding. McKinney flips this relationship, employing an engineered system to teach an important mathematical topic. It's an idea that's sure to fly!

William O'Shea introduces students to nuclear chemistry. While outside of the typical high school chemistry curriculum, the study of nuclear reactions reinforces important concepts such as the periodic table, atomic and molecular structure, and electronic configurations – and instructs on the important concept of radioactivity. A key innovation is the use of animation: traditional instruction is "fused" with a video project, where students bring a nuclear process to life.

Samuel Rauch uses the warming arctic as a theme to introduce and reinforce lessons in geometry. Concepts of area, volume, and arc length are used to analyze loss of arctic ice, change in arctic shipping routes, and extraction of arctic oil and natural gas. With a thorough introduction to the current and projected state of the arctic, Rauch seeks to demonstrate the potential of mathematics as a tool toward understanding this important environmental, economic, and geopolitical issue. What a cool way to apply math!

Maria Stockmal proposes bridge design as a theme to teach math and inspire creativity. Students develop an understanding of ratio, proportion, and symmetry through field trips to local bridges; learn quadratic functions by analyzing arcs from a model suspension bridge; and even design a bridge themselves using computer software. From pre-history's modest efforts to today's modern marvels, bridges connect and unite. As shown here by Stockmal, bridges educate as well.

Charlene Woodland introduces students to the world of photovoltaics, i.e. the generation of electricity from solar radiation. Students build a simple photovoltaic device, test its efficiency with respect to control variables (e.g. color of incident light), and analyze its potential effectiveness for household use. The sun may yet solve mankind's energy challenge; in this unit, Woodland introduces the key scientific principles, and begins a conversation on the eventual place of photovoltaics in the world's energy portfolio. The future is indeed bright!

Through these curriculum units, the Fellows seek not only to enhance math and science learning, but also to introduce – indeed, to advocate – the field of engineering as a future career option. Technology is a dominant theme in today's world. To its masters await great opportunities. Ensuring today's youth can become tomorrow's technological leaders is an admirable goal – and one the Fellows join me in championing.

Paul R. Van Tassel

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