An Integrated Three-Year High School STEM Curriculum Based on the Global Grand Challenges (Resource Exchange)

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The Integrated Global STEM Challenges Curriculum

STEM education holds the promise of helping students understand how technologies work, and increasing problem solving and innovation (Bybee, 2010). However, too often is STEM education merely a rebranding of the regular siloed disciplines (Sanders, 2009) or a combination of math and science only (Bybee, 2010). Truly integrated (or "integrative") STEM education must require learning across all four subjects, situating "scientific inquiry and the application of mathematics in the context of technological designing/problem solving." (Sanders, 2009, p.21.)

The Global STEM Challenges Program (GSCP) curriculum expands upon the curricular standards that high school subjects are bound by, replacing regularly siloed math and science courses with three years of instruction based on challenges in the Grand Challenges for Engineering in the 21st Century. Each unit is designed to teach traditional content, meet all VA state standards, prepare students for IB in 12th grade, and deepen communication, empathy, and design skills.

The themes of the course are food availability (bio and geometry/trig), water (chemistry and trig/algebra 2), and energy (physics and pre-calc.) STEM educators and pre-service STEM teachers could benefit from seeing these connections between content which emphasize a perspectives approach on the phenomenon, instead of a siloed approach to content. We are eager to collaborate with you or your students to share methods for how we designed these units, and how you can design content-heavy context-rich integrated STEM instruction to lift up student interest, access, and outcomes.

Bybee, R. W. (2010) "What Is STEM Education?," *Science (80-.).*, vol. 329, no. 5995, pp. 996 LP – 996

NAE Grand Challenges for Engineering Committee. NAE Grand Challenges for Engineering. Washington, DC: National Academy of Engineering; 2008.

Sanders, M. (2009). STEM, STEM Education, STEMmania. *The Technology Teacher*.

Details of Example Unit 2. Design a microscope and learn about pathogens

Unit duration: 3-5 weeks, Food Availability
Grand Challenge: Design the Tools of Tomorrow, (organizing theme: Sustaining Life on Earth)

Students identify a pathogen that impacts crop production for a stakeholder, and learn about how it survives, then determine the scale needed to identify the pathogen in the field. Students will learn about backwards design and dismantle binoculars investigating how light bends through prisms and lenses modeling the light path with accurate lens ray diagrams. Using appropriate angle terminology, students will determine the magnification needed to see their pathogen and design and test a conceptual model of a two-lens system with the binocular lenses to see it. Students will ultimately design and prototype a hand-held microscope to meet the actual needs of their stakeholder and provide the specifications for manufacturing and assembly as well as commentary on the success of the design to their stakeholders in a written or oral presentation.

9th-grade Units, Food Availability Theme
(State standardized tests: Biology & Geometry)

1) Design a flexible room plan to support productive group inquiry and learn about ratios, composite figures, nature of science, and defining a challenge.

2) Design a portable microscope to identify pathogens on crops and learn about life, cells, optics, geometry, and backwards design.

3) Design a therapeutic food and delivery system for the hungry and learn about macromolecules, digestion, and energy, systems of linear and quadratic equations, and 3-D printing.

4) Design a greenhouse system to cultivate a crop and learn about respiration, photosynthesis, efficiency, triangles, conceptual models and elevations.

5) Design a food waste system to minimize food and energy waste and learn about climate change, nutrient cycles, decomposition, surface area and volume, CAD.

6) Design a protein to ease lactose intolerance and learn about analytic exponential models, similarity and congruency, genetics, and 3-D printing.

10th-grade Units, Water Theme
(State standardized tests: Chemistry & Algebra II)

7) Create a water filter to be used at a specific site in India, Canada, Australia, or Kenya and learn about circles, Reimann Sums, chemical properties and site analysis.

8) Design a digital tool to communicate specific data to a Chesapeake Bay stakeholder and learn about ecosystems, chemical cycling, pH, dissolved O_2, functions, and programming.

9) Design a tool that can collect released gases and analyze solids from an ice core sample and learn about exponential functions, solubility, gases, climate change, and circuitry.

10) Design a chemically powered product for a specific heating or cooling application and learn about dissolution exothermic/endo reactions, normal distributions, human-centered design, and anthropometrics.

11) Design a desalination unit for water capture and purification and learn about phase changes, thermodynamics, regressions, rational functions, and component testing.

11th-grade Units, Energy Theme
(Focus on Physics and Pre-Calculus, no state tests)

12) Design a tidal-driven electric generator and learn about gravity, electromagnetic induction, trig, integrals, and alternative energy technology.

13) Design a solar charging device for a cell phone or other small electronic device and learn about work, energy, and power, derivatives, and solar technology.

14) Design a speculative design solution for space debris and learn about circular & projectile motion, 2nd integrals and derivatives, and animation.

15) Design an automated sensor-response system for a greenhouse and learn about composite functions, statistics, cognition, complex circuitry and programming.

16) Design a secure three-part digital password and learn about electromagnetic spectrum and optics, compositional and transformational graphs, ergonomics, cybersecurity and privacy.

Want to design your own integrated STEM unit based on the Grand Challenges? Reorient your thinking from discipline-specific to a perspectives approach that centers a driving interest and explores it through various lenses. It won't look like normal sequencing and you might need help, but that's how to make it integrated!

 Be in touch! Katey.Shirey@knowlesteachers.org