Career *and* Technical Education Partnership
OF NEW JERSEY

science technology engineering & mathematics

Socially Responsible Engineering & Technology

A Model Program of Study for New Jersey High Schools

STEM Career Cluster

Engineering & Technology Pathway

Socially Responsible Engineering & Technology Program of Study

Overview

Introduction:
The College of New Jersey's Center for Excellence in STEM Education has partnered with the New Jersey Department of Education to create a model Program of Study in Engineering & Technology for NJ high schools. This initiative, called the Career and Technical Education Partnership (CTEP) is supported by funds from the federal Carl D. Perkins Career and Technical Education Act of 2006 (http://ctep.pages.tcnj.edu/).

Four courses (for grades 9-12) have been developed by our state's top STEM educators, business leaders and industry professionals. The curriculum is project-based, standards-driven and connects cutting edge design challenges with career preparation and 21st Century Skills development. Additionally, the curriculum is correlated with Technology Student Association (TSA) competitive events and activities. High school students enrolled in this Program of Study will have the opportunity to graduate with postsecondary credit that can be applied toward several STEM-related degree programs at two and four-year institutions of higher education around the state.

Purpose:
The *Socially Responsible Engineering & Technology* Program of Study fosters innovation, problem-solving and 21st Century Skills as it prepares students for successful entry into STEM-related postsecondary studies and career paths.

The curriculum integrates all four STEM disciplines cohesively and purposefully into powerful real-world lessons, activities and design problems. These realistic contexts engage, motivate and excite students. They lead to a deeper understanding of the interconnectedness of STEM subjects and careers, providing students with the tools they need to make informed decisions about their future education and career goals.

Beginning in Year 1, snapshots of both traditional and emerging fields of Engineering & Technology are linked to real-world design challenges. By Year 3, students are engaged in more dynamic and complicated thematic design problems as they take on the roles of professionals in high-demand careers such as Systems, Medical and Ocean Engineering. By Year 4, students will have developed cutting-edge technical skills (e.g. CAD/CAM drafting, technical drawing, technical writing, tool/machine/material safety) and will embark on a student-driven capstone course in a specific area of Engineering & Technology, which they choose. They must select the design problem and an industry mentor, as they work toward a viable, real-world, socially responsible solution, which they will present to stakeholders.

Theme:
Engineering & Technology professionals in the 21st Century cannot do their jobs effectively without considering how their work impacts the world around them. Designing a new product, system or device today requires knowledge of human, environmental, ecological and many other factors. The Program of Study curriculum prepares students to design with social and environmental responsibility in mind.

Social Responsibility: is an ethical ideology or theory that an entity, be it an organization or individual, has an obligation to act to benefit society at large. This responsibility can be passive, by avoiding engaging in socially harmful acts, or active, by performing activities that directly advance social goals.

Spiraling Themes: The following themes spiral or reoccur throughout each course in the POS:

- *7* Resources of Technology
- Systems
- CAD/CAM/Drafting
- Safety
- Engineering Design Process Steps
- Integration of Math & Science
- Documentation/Portfolio
- Technical Drawing
- Technical Writing
- Ethics (debate)
- 7 Areas of the Designed World
- History of technology
- 21st century Skills
- STEM Careers
- Impact on Society
- Participation in TSA
- Gender Sensitivity/Neutrality
- Social Issues
- Presentations Skills
- Product Life Cycle

Drawing; CAD/CAM: is not offered as a stand-alone course within the program of study. Instead, these skills are developed throughout the four courses. In Y1, basic engineering drawing/dimensioning and 2D/3D perspective drawing and skills are introduced and assessed, mostly by hand, then paralleled in any CAD software. Students will become more familiar in CAD in year 2, then transition to animations and CAM applications by Y3. In the Capstone Course, students demonstrate mastery, having been prepared to test out of any CAD 1 course at the postsecondary level. CAM equipment will vary from school to school, but variations are suggested as part of activities or design briefs.

Facilities: It is assumed that all teachers adopting these courses have the facilities to accommodate both design and prototyping aspects of the engineering design process. They may not have two separate rooms, but they would be able to utilize computers (software and Internet) and a clean space for drawing and documentation. It is optimal for a teacher to have a complete shop and design laboratory, but activities are based on basic machine tools (band saw, drill press, disc sander, etc.). Given the Internet, Social Networking Technology, Cell Phones Applications, Tablets and Free Software that many students have access to, it can be assumed that these course will exist in a 24hr. classroom that also utilizes as much educational technology as possible. It can also be assumed that teachers have access to basic scientific testing and measuring equipment, but these are named explicitly in the curriculum and suggestions or variations are explained (for example, if a pneumatic structure testing device is not available to test a bridge, an explanation of how this might be done across a gap with a hanging bucket of sand and a bathroom scale is provided). A video series highlighting these types of modifications will be added to the CTEP-STEM website.

CTEP-STEM Website: http://ctep.pages.tcnj.edu Acts as an online toolkit for teachers, administrators, counselors, parents and students to be used in conjunction with the curriculum.

Teacher Qualifications: It is strongly recommended that the teachers adopting this POS have teaching experience in the field and hold a K-12 Technology Education endorsement from NJ.

Standards:
NJCCCS 8.2, 9.4 in STEM, 5, 4 and Common Core in Language Arts Literacy and Math.

Industry Standards:

National Occupational Competency Testing Institute (NOCTI): http://www.nocti.org/Blueprint.cfm	Occupational Safety and Health Administration (OSHA): http://www.osha.com/courses/
• Workplace Readiness • Electrical Construction Technology • Electrical Occupations • Electronics • Electronics Technology • Industrial Electricity • Industrial Electronics • Manufacturing Technology • Pre-Engineering/Engineering Technology	• Environmental • Construction Industry • General Industry • Occupational Safety

Curriculum Template: The "Unit Overview Template" used is the product of another initiative led by the New Jersey Department of Education, Office of Academic Standards, in partnership with the New Jersey Association for Supervision and Curriculum Development (NJASCD) and the New Jersey Principals and Supervisors Association (NJPSA). The project was undertaken with the assistance of New Jersey content area supervisors, curriculum coordinators, and teachers during spring-summer 2009. The goal of the project was to design exemplar unit plans and accompanying lesson plans aligned with the 2009 Core Curriculum Content Standards that may be used by districts as models for the development of local curricula. The Unit Overview Template is designed to summarize the content and objectives for the unit, outline lessons and assessments that support the unit, and provide links to documents that facilitate delivery of the unit, such as student materials, background information, resources, and performance rubrics.

The DOE's template was modified for the *Socially Responsible Engineering & Technology* Program of Study to better encompass project-based learning. The following enhancements were incorporated: Engineering Design Process Steps, Design Briefs, Assumptions, Correlations of CPI's to Unit Learning Targets and Assessments.

Courses

Year 1: Technology, Engineering & Social Responsibility

This course serves as an introduction to engineering and technological studies, with a special emphasis on the interrelationships of STEM disciplines and 21st Century Knowledge and Skills in the pursuit of solving real-world problems within a context of social responsibility themes. Students will learn about safety while working with tools, machines, materials and processes as they develop their engineering and technological literacy through lessons and hands-on activities.

- Unit 1 Got Design? Introduction to the Engineering Design Process (Materials & Processes)
- Unit 2 Can I Borrow a Pencil? (Structures, Mechanisms, Circuits, Mechanical Advantage)
- Unit 3 Recycled Light Source (Electronics)
- Unit 4 How Does this Work? (Reverse Engineering)
- Unit 5 Is Recycling Worth the Time? (Rube Goldberg, Control Systems, Power Systems)
- Unit 6 Got Efficiency? (Alternative Energy & Conservation)

Math- Algebra or Geometry
Science- Biology

Year 2 – Sustainable Engineering Design

Building upon what was learned in the Y1, students will conduct a deeper study of each area of the designed world through corresponding units. Each unit will cover multiple technological products and systems used to solve various engineering problems in the past, present and future, providing a context for exploring major engineering disciplines, other STEM-related occupations, and the higher-education pathways leading to them. In each unit, students will encounter new tools, materials, machines and STEM-related knowledge that they must use to identify and analyze both natural and human-made problems, evaluate risks and examine alternative solutions for resolving or preventing them with social responsibility in mind.

- Unit 1: Fully Charged (Energy & Power)
- Unit 2: Nature as Model, Measure, Mentor (Biotech/Manufacturing)
- Unit 3: Constructing Accessibility (Construction)
- Unit 4: Passing it Along (Transportation)
- Unit 5: Engineering Prosthetics (Medical Technology)
- Unit 6: Clearing my Pathway (Communication & Information)

Math-Geometry or Algebra II
Science - Chemistry

Year 3 - Exploring Careers and Issues in Socially Responsible Engineering

This course engages students in more dynamic and complicated thematic design challenges and studies related to specific existing and emerging fields of engineering. Students take on the roles of professionals in high-demand careers such as, Systems, Medical and Ocean Engineering. Working independently and in groups responsible for designing and fabricating sustainable solutions, this course also emphasizes the student's ability to demonstrate global awareness, practice ethical decision making, work within economic constraints and consider policy and regulations. In preparation for the final course in the program of study, it is critical that students demonstrate growth in a variety of areas including creativity, critical thinking, digital citizenry, public speaking, CAD/CAM, application of grade-level (or above) math and science principles, technical writing and leadership.

- Unit 1: Get Ready to Bring Home the Bacon! Preparing for the Interview (Interview Prep, Business Literacy, Communication, Job Readiness, Employability Skills)
- Unit 2: Deadlines! Scheduling a Major Project (Architectural Design, Engineering Math, Project Management)
- Unit 3: What is Your Frequency? (Systems Engineering, Medical Design, Biofeedback, Human Anatomy and Systems)
- Unit 4: Under Pressure (Ocean Engineering, Electrical/Mechanical/Structural Design)
- Unit 5: Planning to Keep it All in My *Site*; Designing the World Around You (Civil Engineering, Geotechnical)

Math- Algebra II, Trigonometry, Pre-Calc or Statistics
Science - Physics

Year 4 - Senior Design Capstone

The Senior Design Capstone is a "student-driven" course structured around a previously introduced theme that the student is interested in exploring in greater depth. It is an opportunity for students to engage in a full-year design process, culminating in the fabrication of a physical product or system that solves a unique problem, demonstrating the student's ability to apply knowledge, skills and abilities honed throughout the program of study.

Under the guidance of the Capstone Facilitator, or teacher, students will select a problem or opportunity in Engineering & Technology that relates to a theme in social responsibility by the end of their junior year and develop research questions they will answer over the summer. Students will also identify resources, such as an industry mentor, from the local and/or global communities as they work toward a viable solution. They will be required to publicize a record of their work online throughout the course of the project so that they are more accessible to potential sponsors and mentors.

Students must be highly motivated to manage their own project in this unique learning environment. Final solutions will be documented and presented to a panel of stakeholders associated with the student's project, and they will be required to write about their experience and publish it in an appropriate forum, either online or in print.

- Unit 1: Introduction to Independent Project
- Unit 2: What's the Problem Here? (Identifying the Problem)
- Unit 3: Now, What am I Going to Actually Do? (Developing the Design Brief)
- Unit 4: What Has Been Done Already and Who Can Help Me? (Investigation and Research)

- Unit 5: Making the Best Choice (Brainstorming, Generation of Multiple Solutions, Select One and Provide a Rationale)
- Unit 6: Innovating and Inventing (Developmental Work)
- Unit 7: Seeing the Design in Action (Modeling and Prototyping)
- Unit 8: Evaluating Success! (Testing Evaluation and Analysis)
- Unit 9: Ready, Set, Share (Documentation and Presentation)

Math- Trigonometry, Pre-Calc, Calc, AP Calc or math analysis
Science- AP Science or structured computer program