STEM Designers

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C25801
Prerequisite(s):	None
Credit:	N/A
Grade Level:	8
Graduation Requirement:	N/A
Coursework and Sequence:	This is the third course in the *Middle School STEM* sequence of coursework.
Aligned Student Organization(s):	Technology Student Association (TSA): http://www.tntsa.org
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/education/educators/career-and-technical-education/work-based-learning.html.
Promoted Student Industry Credentials:	N/A
Teacher Endorsement(s):	001, 013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 101, 121, 122, 123, 124, 125, 126, 127, 128, 129, 157, 210, 211, 212, 213, 214, 230, 232, 233, 400, 401, 402, 413, 414, 415, 416, 417, 418, 440, 449, 470, 477, 982
Required Teacher Certifications/Training:	Teachers who have never taught this course must attend training provided by the Department of Education.
Teacher Resources:	https://www.tn.gov/education/educators/career-and-technical-education/career-clusters/cte-cluster-stem.html Best for All Central: https://bestforall.tnedu.gov/

Course at a Glance

There is no one way to create meaningful learning experiences for students. There are best practices available that data and students say impact long-term student learning. One of those best practices is to put student learning in context with their experiences.

Career and Technical Student Organizations (CTSOs) provide an opportunity for students to display their learning in the classroom and through regional, state, and/or national competition. Work-based Learning (WBL) consists of sustained and coordinated work-based activities that relate to the course content. These activities should occur at every level through a program of study. Below is a listing of possible CTSO connections and WBL activities for this course. This listing is intended to be an idea starter and not a comprehensive listing.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

Putting the classroom learning into real life experiences is often what creates a meaningful learning experience for students, one that lasts beyond the exam and course. CTSOs are a great resource to create this type of learning for your students. They are also a great resource to showcase your students learning through regional, state, and national competitions. Possible connections for this course include the following. This is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management.
- Participate in contests that highlight job skill demonstration, interviewing skills, community service activities, extemporaneous speaking, and job interview.
- Participate in leadership activities such as National Leadership and Skills Conference, National Week of Service, 21st Century Skills.

For more ideas and information, visit Technology Student Association (TSA): http://www.tntsa.org.

Using Work-Based Learning (WBL) in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standards 1.1-1.2** | Invite an OSHA representative to discuss safety protocols.
- **Standards 2.1-2.3** | Invite an Engineer to discuss engineering foundations.
- **Standards 3.1-3.3** | Visit an engineering firm to showcase the design process.
- **Standards 4.1-4.3** | Partner with an industry partner to provide a hands on CAD experience for students.
- **Standards 5.1** | Do a project that is useful to the community.

For more ideas and information, visit https://www.tn.gov/education/educators/career-and-technical-education/work-based-learning.html.

Course Description

STEM Designers is a fundamental middle school course that trains students to define problems and methodically answer the question, *"What is the solution?"* Upon completion of this course, proficient students understand that engineering design is a process of developing solutions to problems and challenges in order to meet the needs of society. Students continue to apply the practices for science and engineering learned in *STEM Explorers* and *STEM Innovators*; however, *STEM Designers* places more emphasis on practices such as using mathematics and computational thinking; designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information. In addition to gaining a deep understanding of the relationship between engineering and design, students who complete this course will learn how both innovation and engineering design result in new technologies that benefit humans.

Note: Students are expected to use engineering notebooks to document procedures, design ideas, and other notes for all projects throughout the course.

Course Standards

1. Safety

1.1 Safety Rules: Accurately **read and interpret safety rules**, including but not limited to rules published by the National Science Teachers Association (NSTA), rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to **distinguish between the rules** and explain why certain rules apply.

1.2 Safety Equipment: Identify and **explain the intended use of safety equipment available in the classroom**. For example, demonstrate how to properly inspect, use, and maintain safe operating procedures with tools and equipment. Incorporate safety procedures and complete safety test with 100 percent accuracy.

2. Introduction to Engineering

2.1 History of Engineering: Research the **history of engineering** using textbooks, the websites of professional societies, scholarly narratives, and explain **how science, technology, and math have influenced its development**. Create a timeline of important engineering milestones, noting the influence of science, technology, and math in the timeline. The timeline may be done via PowerPoint, Prezi, poster, or other graphic format.

2.2 Relationship between STEM: Research and illustrate the **relationship between science, technology, engineering, and math using** a flowchart, Venn diagram, or other graphic organizer. Provide an **example of a design solution** that incorporated at least three of the disciplines and articulate how they each contributed to the design.

2.3 Benefits of Engineers: Research **how engineers in various disciplines** (such as civil, mechanical, electrical, chemical, biomedical, computer, agricultural, industrial, and aerospace) **benefit society through the products and solutions they design**. Write a paper arguing for the discipline that has benefited society the most. Illustrate the claim with specific products and benefits.

3. Engineering Design Process

3.1 Engineering Design Process Evaluation: **Evaluate an existing engineering design**, such as a local bridge or a famous building, providing evidence from exemplars and **design rubrics to justify whether the design meets the specified criteria**. Create a presentation **explaining how the steps of the design process might have been used** to create this feat of engineering, citing historical narratives, published interviews with the architects or engineers involved, and other informational resources. The typical steps of the design process include: identify the problem; identify criteria and specify constraints; brainstorm for possible solutions; research and generate ideas; explore alternative solutions; select an approach; write a design proposal, develop a model or prototype; test and evaluate; refine and improve; create or make a product; and communicate results.

3.2 Alternative Solutions: Practice **exploring alternative solutions in the engineering design process by creating two solutions for an engineering problem**. Test each solution and record the test data. Analyze the test data to determine the differences in the quality for the solutions. Write a conclusion that that argues which solution is best and explains why. Support the explanation with specific evidence obtained from test results. For example, create a solar vehicle that is designed travel as fast as possible. The two solutions should have a single variable that is changed, for example drive and axle gear ratio, wheel size, or solar panel angle

3.3 Engineering Design Process Utilization: **Use the engineering design process and the practices of science and engineering** (see specific practices below) to **develop a solution for a given engineering challenge**. Chronologically **document the entire process** in an engineering notebook. The engineering notebook should have bound, dated, and numbered pages. Use permanent ink to document notes. For example, design a balsa or basswood bridge that has the best performance ratio, maximum capacity divided by mass of the bridge. Tests can be done of various basic structure designs before creating a final design. This test data should be included in the engineering notebook. A hand or digital sketch should be made of the design. Pictures can be taken throughout the process and included in the engineering notebook. At minimum, address the following science and engineering practices:

a. using mathematics and computational thinking;
b. designing solutions;
c. engaging in argument from evidence; and
d. obtaining, evaluating, and communicating information.

4. Fundamental Sketching and Engineering Drawing

4.1 Two Dimensional Design: Present a **two-dimensional design idea using freehand sketching, manual drafting, and computer-aided drafting** (such as SketchUp or AutoCad). Designs should be **made to scale and include dimensions, labels, and notes**. At least one of the designs presented should be an orthographic (multi-view) projection. Use basic dimensioning rules and apply understanding of the use of lines (e.g., object, hidden, center) to inform the design. Sketch principle views of a simple object from the top, bottom, front, back, left side, and right side. For example, create an orthographic projection of a CO_2 dragster or a floor plan for a home.

4.2 3-D Design: Present a **3-D design idea using freehand sketching, manual drafting, and computer-aided drafting** (such as SketchUp, SolidWorks, or Inventor). Designs should be **made to scale and include dimensions, labels, and notes**. Use basic dimensioning rules and apply understanding of the use of lines (e.g., object, hidden, center). *For example, convert the 2-D design in the activity in the previous standard into a 3-D design in the 3-D version of the software used to create the 2-D design*

4.3 Design Model Concept: **Create a scaled model of a design concept**. A digital or manual drafting design should be made of this model prior to building or producing the model. For example, create a digital 3-D design of a product and use a 3-D printer to create a physical model of the design. If a 3-D printer is not available, build a model from materials provided in the class.

5. Final Project

5.1 Final Project: Work in groups **to solve a community or school problem by applying the engineering design process and the practices of science and engineering**. Build a prototype, if feasible, and write a technical report detailing the problem, the design process used, and the solution proposed. Include an evaluation of the quality of the solution, and give a presentation to the class. Be able to justify the final design solution with supporting evidence from the process, including graphic representations and visual aids as appropriate.

Standards Alignment Notes

*References to other standards include:

- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
  - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.