STEAM EDUCATION

H2 GRAND PRIX SPRINT

ENGINEERING AND RENEWABLE ENERGY CTE CURRICULUM

ESTIMATED TIME: 600 MINS.

UNIT OVERVIEW

600 MINUTES

This unit introduces students to 3D printing, engineering design, and digital fabrication. Students will explore the history of 3D printing, its applications in various fields, and how it enables custom manufacturing. Through hands-on activities, students will learn sketching techniques, isometric drawings, slicing software, and 3D printer operations. They will also troubleshoot common printing issues and refine their designs using the engineering design process.
Students will apply these concepts to design, modify, and print functional components for a hydrogen fuel cell vehicle. By the end of the unit, students will understand the full workflow of digital fabrication, from initial sketches to final printed models.

OBJECTIVES

- The student will distinguish between the different types of 3D printing technologies, including FDM and SLA.
- The student will create isometric sketches to visually represent designs.
- The student will prepare 3D models for printing by using slicing software to generate G-code.
- The student will adjust printer settings such as layer height, infill percentage, and support structures for optimal prints.
- The student will identify and troubleshoot common 3D printing failures, including warping, layer adhesion, and over-extrusion.
- The student will follow the engineering design process to design and iterate on a functional 3D-printed part.
- The student will evaluate and improve 3D printed components for a hydrogen fuel cell vehicle based on performance criteria.

STANDARDS

COMMON CORE

Common Core State Standards (CCSS) – Mathematics & Research
CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.
CCSS.MATH.PRACTICE.MP4: Model with mathematics.
CCSS.MATH.PRACTICE.MP5: Use appropriate tools strategically.
CCSS.ELA-LITERACY.WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.

VA:Cr2.1.7a: Demonstrate persistence in developing skills with various materials, methods, and approaches in creating works of art or design.
VA:Cr2.3.7a: Apply visual organizational strategies to design and produce a work of art, design, or media that clearly communicates information or ideas.
VA:Cr3.1.8a: Apply relevant criteria to examine, reflect on, and plan revisions for a work of art or design in progress.

CONNECTED STANDARDS: NGSS

Next Generation Science Standards (NGSS) – Engineering Design
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

SKILLS

Technical Drawing
Understanding of Geometry and Mathematics
Attention to Detail
Spatial Visualization
Problem-Solving
Communication
Continuous Learning
Collaboration
Critical thinking
Design interpretation
Hands-on modeling

STUDENT RESOURCES

Ruler
Pencil
Access to Google Slides and Sheets
Sprint Car Trial Data Log

INSTRUCTOR PREPARATION

Review:

3D Printing Presentation: Sprint Car
Engineering Design Presentation: Sprint Car
Design Matrix
Sprint Car Trial Data Log

Print and review:

Isometric Grid Paper
Sprint Car Test Log
Isometric Drawing: This contains 12 unique drawings. Each student just needs one of the 12. You will need to print the number you need and cut them to pass out to students.

Note:
You will need access to a 3D printer during this unit.
You will need slicing software for your printer downloaded on your computer.
Consider partnering with another teacher whose students have CAD experience. These students could potentially develop CAD files from students hand sketching. The other option is students can choose from Horizon provided modifications,
These files are located: https://www.horizoneducational.com/h2gp-sprint-car-kit/p1772

This unit includes another speed trial for the Sprint Car. Plan to have track ready or large racing space.

SUPPLEMENTAL RESOURCES

Isometric Drawing - Simplified

For FDM type printer, show video:
https://www.youtube.com/watch?v=GxLjDNrQBgs
For SLA type printer show video:
https://www.youtube.com/watch?v=8a2xNaAkvLo

VOCABULARY

3D Printing - A process of creating three-dimensional objects by adding material layer by layer.

Additive Manufacturing - A production method where material is added rather than removed, as in traditional manufacturing.

Slicing Software - A program that converts 3D models into layers and generates instructions (G-code) for 3D printers.

G-code - A programming language used to control 3D printers, defining movements, speeds, and layer deposition.

Fused Deposition Modeling (FDM) - A common type of 3D printing where melted plastic is layered to form objects.

Stereolithography (SLA) - A type of 3D printing that uses a UV laser to harden liquid resin, creating high-detail models.

Isometric Drawing - A sketching technique that represents three-dimensional objects using a 120-degree angle grid.

Support Structures - Temporary structures printed to support overhanging parts of a model during the 3D printing process.

Infill - The internal structure of a 3D printed object that determines strength and material usage.

Layer Height - The thickness of each layer in a 3D print, affecting resolution and print time.

Print Bed Adhesion - The ability of a 3D print to stay attached to the printer's build surface during printing.

CAD (Computer-Aided Design) - Software used to create detailed digital models for 3D printing and engineering projects.

Warping - A common 3D printing issue where prints curl or lift at the edges due to uneven cooling.

Over-extrusion - A print defect where too much filament is extruded, causing blobs or rough surfaces.

Under-extrusion - A defect where too little filament is extruded, leading to gaps or weak layers in the print.

LESSON PLAN

ENGAGE

Duration: 30 mins.

STEP 1	Pre-Assessment
STEP 2	Have students draw a KWL chart and complete the K and W for 3D Printing K (Know): What do I already know about this topic? W (Want to Know): What do I want to learn?
STEP 3	Launch 3D Printing Sprint Car. Show Slides 1-3.
STEP 4	Allow students to see the classroom 3D printer. Lead a class discussion asking students which type of 3D printer we have in the classroom? Show the materials available for 3D printing.
STEP 5	For FDM type printer, show video: https://www.youtube.com/watch?v=GxLjDNrQBgs For SLA type printer show video: https://www.youtube.com/watch?v=8a2xNaAkvLo

EXPLORE

Duration: 90 mins.

STEP 1	Show slides 4-5
STEP 2	Provide students with isometric grid paper and allow them to draw the cube on slide 5 following the directions. They should use a small portion of the paper and save room for step 3.
STEP 3	Have students use the same grid paper to draw while you show video instructions: Isometric Drawing - Simplified Pausing video often to allow students to follow along.
STEP 4	Provide students with one of the 12 shapes from Isometric Drawings to draw and dimension.
STEP 5	Show slide 6 Students use their rulers to dimension the two drawings they just created. Walk around and help students as they work. Specify whether they should us mm or in.

STEP 6	Show slide 7
STEP 7	Deomonstrate using Thingyverse to find and download an object.
STEP 8	Show slide 8-9
STEP 9	Demonstrate loading your file into your printer's slicing software.
STEP 10	Show slides 10-13
STEP 11	Demonstrate setting up file for printing on your software as discussed in slides 10-13
STEP 11	Set file to print and let students take turns seeing printer in action. Explain the process takes up to several hours.

EXPLAIN

Duration: 180 mins.

STEP 1	Show Slide 14 Launch a new cycle of the engineering design process. Refer back to the Engineering Design Presentation, presenting the steps again as necessary to get students to reflect on a new problem that could be solved through the design and 3D printing process.
STEP 2	Durining the "Imagine" phase students should use their new drawing skills to sketch and dimension an idea for improving their Sprint Car.
STEP 3	During the planning phase students use the design matrix to choose the best of their team's ideas.
STEP 4	Have students present their teams consensus idea using a 1-2 slide presentation using Google slides.

ELABORATE

Duration: 100 mins.

STEP 1	Support students in creating a CAD prototype of their idea. This might involve guiding students to consider using one of Horizon's pre-designed 3D printing files. You could also consider partnering with another teacher to have students with CAD skills develop the CAD files based on students sketch.
STEP 2	Guide students in printing their 3D design prototypes. Watch closely but allow students to work through themselves as much as possible. This can take several days of students taking turns using the printer.
STEP 3	Show slides 15-16, discussing what the different modes of printer failure look like.
STEP 4	Restart any failed prints, modifying settings as necessary.

EVALUATE

Duration: 20 mins.

STEP 1	Post Assessment
STEP 2	Have students complete the Learned portion of their KWL Chart L (Learned): What have I learned?

EXTENSION

Duration: 180 mins.

STEP 1	Repeat the Sprint Trails with the new prototypes with the 3D printed modifications.
STEP 2	Provide students with a new log for data. After the trial, create a "Redesign 2" Tab of the Sprint Car Trail Data Log.
STEP 3	Students calculate statistics for third trial, log changes made and compare this trial to the previous two trials.