engineering 4 us all

UNIT

Engineering is Creative - Unit 2 Wind

Quick Look

e4usa+ Making

Thread Concentrat... Green, Blue, Yellow
Grade Level: 9 (9-12)
Choose From: 13 lessons and 22 activities

Purpose/Summary

Essential Question: How does creativity relate to engineering? Students engage in a guided whole-class engineering challenge tethered to a teacher-provided global issue which relates to a local problem. Students engage in creative thinking and problem-solving as they design, construct, test and evaluate their product(s) to address a need. In this unit, the specific need is to provide reliable and sustainable energy through the design of a wind turbine.

Engineering Connection

Who do engineers design for and how does the product impact the user? How do engineers go from problem to product? How do we know our design works?

In this unit, students will experience engineering design and create a prototype to test as well as have an opportunity to debrief. They will also make a formal transition from group work to teamwork.

Unit Overview

Connect with Engineering: The role of civil engineers in providing sustainable wind energy will be highlighted.

Engineering in Society: Engineering design can impact society and choices/decisions may not occur in isolation.

Engineering Professional Skills: Students will be introduced to teamwork.

Engineering Design: Design is a process that requires us to test how well we meet our initial goals which are often established through stakeholder inputs.

Learning Outcomes

Engineering Professional Skills

PS.A	Use various engineering communication methods.
PS.B	Collaborate effectively in a team.

Connect with Engineering

CE.A	Iterate and evolve the definition of what it means to engineer and be an engineer.

Engineering in Society

ES.A	Explore the impacts of past engineering successes and failures on society as a whole.
ES.B	Recognize and investigate the world's greatest challenges and the role that engineering plays in solving these challenges (e.g., Engineering Grand Challenges, UN sustainability goals, etc.).

Engineering Design

ED.A	Identify and describe a problem that can be solved with a potentially new product or process.
ED.C	Plan and conduct research by gathering relevant and credible data, facts, and information.
ED.D	Articulate appropriate STEM practices and principles in the design.
ED.E	Evaluate solution alternatives and select a final design by considering assumptions, tradeoffs, criteria, and constraints.
ED.F	Create a prototype.

ED.G	Create and implement a testing plan to evaluate the performance of design solutions.	
ED.I	Articulate and reflect on how an engineering design process could be applied to solving a problem.	

Misconceptions

- Misconception: Engineers work in isolation, without input from others, such as stakeholders, team members.

More accurate concept: Engineering does not happen in isolation. Engineering teams work together to develop a solution. Engineers must communicate with stakeholders to ensure that the solution is appropriate for the people who will use it.

- Misconception: Engineers focus on technology and do not need to learn how to write.

More accurate concept: Engineers need to be able to communicate their ideas, work and results to others. Good communication, including strong writing skills are an essential part of their tools for communication.

- Misconception: Energy is always reliable and sustainable.

More accurate concept: Reliable energy is an important issue for all communities. Yet, there are some places in the world, and in the United States, where people do not have access to reliable energy. This may be due to limited access, remote locations, poor infrastructure, natural disasters, economic or political issues.

- Misconception: Wind is not a valid source of energy.

More accurate concept: Wind energy is a valid and viable source of energy and offers many advantages over other power sources, which explains why it's one of the fastest-growing energy sources in the world.

- Misconception: All design is engineering design; there's no difference between engineering and, say, artistic design.

More accurate concept: There are differences between different uses of the word “design”. Artistic design is evaluated almost entirely subjectively. Whether a work of art is aesthetically pleasing or not is up to the person viewing the art. Successful engineering design must meet certain criteria and constraints.

- Misconception: Engineering design is only the part where you come up with an idea and build it (and does not inherently include research, delimiting the problem, testing and/or improving).

More accurate concept: The engineering design process requires research, delimiting the problem, brainstorming and choosing a possible solution, designing a prototype, building a prototype, testing and evaluating the prototype, improving the design, and sharing the results. All of these steps are part of the engineering design process.

- Misconception: Engineering design is making a plan on paper or on the computer.

More accurate concept: The engineering design process involves many steps to take an idea and transform it into a solution. The process involves brainstorming, planning, research, building a prototype, testing the prototype, reflecting on the results, communicating the results, improving the design, retesting and improving the design.

- Misconception: Engineering design is essentially trial and error.

More accurate concept: Engineers work in project teams and follow an accepted design process that helps them design, build, and iterate upon any project, without having to engage in trial and error.

- Misconception: Contributing to a team's success at the beginning of a project means having great ideas (as opposed to offering all ideas); that bad ideas are not valuable; that individuals are more or less naturally creative and will be the ones to come up with ideas (as opposed to team members helping each other).

More accurate concept: Contributing to a team’s success at the beginning of a project means: working as a team, generating as many ideas as possible, being open to all ideas, creating a safe space for others to be heard and share ideas, building on the ideas of others, sharing and accepting all ideas even if they seem wild, not criticizing an idea, not stopping yourself from adding an idea even if you think it isn’t good. The best ideas come from brainstorming sessions where team members listen to each other and work together on the solution.

- Misconception: Students may think that there is always one best design, or that the most creative and innovative designs are best, or ones that use high tech materials are best, etc.

More accurate concept: When engineering a solution to a problem there is never one best design. Sometimes the most innovative and creative ideas fall short of the needs for the design. An idea that seems innovative and uses high tech materials may or may not be the best solution for the problem. Engineers need to always be asking if the design meets the set of criteria which solves the problem for the intended users.

- Misconception: Voting is the best way to decide on an idea for a team to pursue.

More accurate concept: Using a prioritized set of criteria and a common, agreed upon scoring system is an effective way to narrow down ideas that fit the requirements and offer the best possible solutions. Voting can be part of this process to narrow down ideas, but decisions should focus on what is the best possible solution, rather than on what preferences might be, and be based on research and science.

- Misconception: Using objective analysis means that people are not swayed by their own preference or the preferences of others.

More accurate concept: Objective analysis is an ideal to strive for. While we may try to be objective, people will always be unconsciously subjective. Please encourage students to explore subjectivity and objectivity as related to engineering mindsets and practices.

Teaching Challenges

- You may be unfamiliar with using typical engineering tools (Technical Drawing or drafting tools and computer aided design tools- CAD). Lesson 2.7 covers some basics in technical drawing and includes supplemental resources including resources for drawing 3-d shapes and Onshape's Intro to CAD program. These are all great resources to get familiar with technical drawing.
- You may be unfamiliar with the process of teaching teaming to students. Lesson 2.1 is an introduction to teaming. Try to support and encourage students as they develop cooperative skills and teamwork (as opposed to group work) skill-building.
- It can be challenging to support multiple groups during the design process. Give yourself time and space to work with groups who may need guidance. Try to create an atmosphere where students can work productively in their teams. Allow time for students to engage in the process and time to reflect.
- This may be your first experience teaching engineering. Hopefully, exploring engineering in Unit 1 helped you, as a teacher, to discover an engineering identity and that you have a better appreciation for engineering.
- Many students (and teachers) may not begin the course with the growth mindset that failure is still learning and may become frustrated when their designs fail on early trials. Help students understand that failing is an important part of learning and a necessary and important part of the engineering design process.

Unit Materials

For the Class

- Materials:
  - a 10-30 inch fan per test station (2-3 stations in total)
  - one multimeter per test station (2-3 stations in total)
  - a 30, 50 or 100 ohm resistor per test station (2-3 stations in total)
  - one anemometer or air speed meter (optional)
  - a hot glue gun
- Cost: $65-150

For each Group/Team

- Materials:
  - Wind Shelter materials
    - newspaper (or similar type paper) - 10-15 sheets
    - 1 roll masking tape
    - 3 rulers
  - KidWind Advanced Wind Experiment Kit (Classroom Pack)
  - additional material for making blades (e.g., wood veneer, plastic bottle, canvas, thick cardboard)
  - sticky notes or poster paper
- Cost: $500

For each Student

- Materials:
  - Activity 2.12.1 Product and Process Evaluation Student Handout
  - Comprehensive Assessment of Team Member Effectiveness (CATME) Teamwork Rating Scale
  - Wind Turbine Model at Computational Thinking Activities with Matlab (Mathworks)
  - e4usa Team Performance Rubric
  - e4usa Wind Turbine Model Handout
  - Materials for sketching a design
    - isometric graph paper (may be printed on existing paper as needed)
    - pencils
    - erasers
    - paper
    - a physical object with its dimensions measured and provided, such as a block or object made with wooden blocks (optional)
    - computer-aided design (CAD) software (optional)
- Cost: $0

*All costs are estimated, and will vary by your choice of materials. Costs can be lowered by using free sources or items you have previously acquired. Please note that some materials are optional.

A look ahead to prototyping in Units 3 & 4

Teacher and student-identified materials and tools needed for constructing, testing, and iterating a functional prototype will vary. Costs can be minimized by utilizing recycled, repurposed, or donated materials.

Related Lessons and Activities/Unit Schedule

Please refer to the Unit 2 Pacing Guide for the suggested timeline for Unit 2. Please use this to plan out lessons. You may also want to make a copy to mark up and use as a checklist to keep track of what activities/assignments your class has completed. This can be especially useful if you have multiple classes working through the unit at different paces.

The assessment details can be found in the lesson guides.

The Units 1-2 video provides a big picture of what is to come as you begin the course. Watch it before beginning these units. Additional shorter videos are also provided to provide tips and tricks and to help you plan ahead.

Lesson Name (duration)	Lesson Description	Activity (duration)
Lesson 1.0 - Classroom and Laboratory Safety [time varies] Video: Lesson 1.0	*Consider revisiting the lesson on safety again as you begin Unit 2*	
2.1 Introduction to Teaming [100 min; 160 min with 2.1.2] Video: Lesson 2.1	Introduce teamwork and characteristics of a high functioning team. Model the wind shelter in CAD.	Activity 2.1.1 Wind Shelter Design [75 min] Activity 2.1.2 Mates in CAD [60 min]
2.2 Community Based Problems [90-95 min; 155 min with 2.2.2] Video: Lesson 2.2	Investigation of access to energy, both as an Engineering Grand Challenge and for some areas, a local community issue.	Activity 2.2.1 Energy in the Community [60 min] Activity 2.2.2 Wind Turbine Prior Solutions in CAD [60 min]

2.3 Introduction to the Engineering Design Process [50 min] Video: Lesson 2.3-2.6	Recognizing multiple models exist for the engineering design process (EDP), the class creates their process of engineering design activities.	Activity 2.3.1 Engineering an Engineering Design Process [45 min]
2.4 Problem Definition [142 min]	Students are presented with an access to a reliable energy problem and asked to design a solution. Students research the science behind wind energy and the process of harnessing it.	Activity 2.4.1 Improvised Wind Turbine Problem [107 min] Activity 2.4.2 Research the Science [35 min]
2.5 Ideation [50 min]	Innovative ideas and solutions are often created through brainstorming. Brainstorming requires team synergy to build upon one another and to promote an environment that allows for the sharing of thoughts and ideas.	Activity 2.5.1 Brainstorming [45 min]
2.6 Design Selection [153 min]	Class decides on a solution design using specified criteria and a justified scoring system.	Activity 2.6.1 Mathematical Modeling [60 mins] Activity 2.6.2 Design Selection [80 mins]
2.7 Disciplinary Modeling [95-215 min]		Activity 2.7.1 Disciplinary Modeling Infographic [90-200 min]

2.8 Prototype Creation [110-115 min; 175 with 2.8.2] Video: Lesson 2.8-2.10	Prototype 1.0; Teams (3 or 4 members) will build their own prototypes.	Activity 2.8.1 Prototype Creation [95-100 min] Activity 2.8.2 Model Your Turbine Blade in CAD [60 mins]
2.9 Prototype Testing [100 min; 150 with 2.9.2]	Does this "work"? An important part of the design process is to test whether the design works as expected.	Activity 2.9.1 Prototype Testing [90 min] Activity 2.9.2 CAD Prototype Testing [45 min]
2.10 Design Iteration [85-90 min: 120-150 min with 2.10.2]	Testing data improves design iteration.	Activity 2.10.1 Design Iteration [80-85 min] Activity 2.10.2 Design Iteration in CAD [60 min]
2.11 Design Communication Through Posters [130 min] Video: Lesson 2.11-2.12	Share results of the design process with classmates. Discuss design process, effectiveness of design, team effectiveness.	Activity 2.11.1 Gallery Walk [125 min]
2.12 Product, Process and Team Evaluation [130 min]	Discuss the processes, ethical implications, and performance of the solution and the teamwork.	Activity 2.12.1 Product, Process, and Team Evaluation [125 min]
2.13 Introduction to the MyDesign Portfolio [100 min]	Introduce the MyDesign Portfolio.	Activity 2.13.1 Introduction to the MyDesign Portfolio [90 min]

Worksheets and Attachments

Unit 2 Wind Pacing Guide

Visit [www.teachengineering.org/curricularunits/view/e4usa-unit2b-wind-engineering-is-creative] to print or download.

Supporting Program

Engineering for US All (e4usa)

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