Unit 6 Guide - Engineering is Iterative

Driving Questions

- What is design, iteration and testing?
- Why is a final design report important?

Description

Students build and test a prototype of a solution they have designed in teams to address a local problem associated with a global issue. Students use what they learn from testing the prototype to redesign their solution through iteration. Teams culminate this unit by generating a comprehensive engineering design report and presentation.

Key Concepts

Connect with Engineering: Students explore and apply ethics to their designed solutions.
Engineering in Society: As students are designing a solution that could cost up to $1000, they consider what issues they will face as they scale their solution up.
Engineering Professional Skills: Students communicate within and beyond their teams about their engineering design work. Teams update their project management plans as they analyze test results and consider iteration. Students and their teams evaluate their teamwork as individuals and as whole teams.
Engineering Design: Student teams take their design plans and use them to create a prototype. After creating testing plans that are evaluated by content experts, tests are conducted. Data is analyzed and summarized. Iteration is at least planned, if not conducted. External evaluators provide summative feedback to the student teams. Finally, teams review their engineering design process work itself.

Learning Outcomes*

Connect With Engineering

CE.C	Explain and apply ethical considerations when exploring an engineering problem.	

Engineering in Society

ES.D	Identify and analyze issues when bringing a solution to scale.	

Engineering Professional Skills

PS.A	Apply strategies to collaborate effectively as a team.	
PS.B	Use various forms of communication (oral, written, visual).	
PS.C	Develop, implement, and adapt a project management plan.	

Engineering Design

ED.B	Identify appropriate stakeholders and content experts and evaluate their input.	
ED.D	Articulate appropriate STEM practices and principles in the design	
ED.E	Evaluate solution alternatives and select a final design by considering assumptions, trade-offs, criteria, and constraints.	
ED.F	Create a prototype.	
ED.G	Create and implement a testing plan to evaluate the performance of design solutions.	
ED.H	Apply iteration to improve engineering designs.	
ED.I	Articulate and reflect on how an engineering design process could be applied to solving a problem.	

Misconceptions

- *Misconception*: Testing plans are a waste of time.

  More accurate concept: Testing and retesting prototypes is an important part of the engineering design process. Before a prototype is built, a testing plan must be in place so that ways of measuring success and failure are known.

- *Misconception*: Failed prototypes promote discouragement.

  More accurate concept: Failed prototypes are an important and expected part of the design process. New information to improve the product comes from failed prototypes.

Failed prototypes promote deeper understanding and new learning opportunities. It is important to distinguish between failure and design failure.

- *Misconception*: Iterations are a waste of time.

  More accurate concept: Iterations are essential to the engineering design process and lead to better solutions to the problem. At least one iteration is necessary to allow students to improve upon what they learned from using their testing plan and their data analysis.

Teaching Challenges

- It is challenging to establish comfort with failed design. As students work, remind them that designs go through an iteration process which leads to new innovations. We don't expect the designs to work as planned when they begin. In fact, we expect there to be issues to solve at every step. The iterative process will help them get to the next level in their design. This is the time to experiment with the design, address the issues with creative solutions and rethink if their design solves the problem. It's important to discuss design failure. Designs fail, however, people do not while they are utilizing the engineering design process
- Students are likely to feel bad about failing. It’s normal to feel frustration when something doesn’t work the way you planned and hoped. Remind students that because design is iterative, they will have a chance to improve upon their designs.

Lesson and Content Overview

Lesson Name (duration)	Lesson Description	Activity
6.1 Prototype Planning and Creation [285-295 minutes] Video: Lesson 6.1 - 6.3 and 6.5 - 6.6	Teachers instruct students about all necessary safety issues and skills for prototype construction. Students learn to create S.M.A.R.T. goals and use that skill to create goals for prototype creation. Students make a plan for prototype construction and then implement it.	1.0 Classroom and Laboratory Safety [5-15 min] 6.1.1 S.M.A.R.T. Goal Setting Goal Setting [30 min] 3.8.1 Prototype Construction Planning [33 min] 3.9.1 Prototype Creation [210 minutes]

LIVE

6.2 Team and Design Check-In [40 minutes]	Teams complete the Team Performance Rubric and the Team and Design Check-in	6.2.1 Team and Design Check-In [35 minutes]
6.3 Testing [165 minutes]	Teams create a testing plan and then implement that plan.	6.3.1 Test Planning [65 minutes] 6.3.2 Test Implementation [85 minutes]
6.4 System Integration (optional) [170 minutes] Video: Lesson 6.4	Teams learn how to create Activity Diagrams and practice on a Rube Goldberg example. Teams then plan and execute systems integration.	6.4.1 Rube Goldberg Interactions [30 minutes] 6.4.2 Systems Integration [120 minutes]
6.5 Iteration [125 minutes]	Team synthesize and summarize their results and make plans for iteration.	6.5.1 Iteration Planning [120 minutes]
6.6 Reflection [150 minutes]	Teams assess their engineering design decisions. Individuals and teams assess their teaming contributions.	6.6.1 Design Reflection [75 minutes] 6.6.2 Teaming Reflection [55 minutes]