Engineering Designs to Solve Problems

Companion Lesson to X-STEM All Access Episode "Real-Life Robotics"

Grade/ Grade Band 6-12	**Topic:** Engineering Design	

Brief Lesson Description: Robotics Engineer and Entrepreneur Jasmine Lawrence has combined her love of science and engineering to solve real-world problems. This lesson emphasizes the engineering design process. It can be a culminating activity to a unit on Forces and Motion with lessons on Newton's Laws of Motion. Students will use their knowledge of simple machines to design a device and make a prototype that solves a problem facing senior citizens like their grandparents and/or a person with limited mobility.

Performance Expectation(s):
NGSS 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.
NGSS MS-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

Specific Learning Outcomes:

1. Students will use the design process to solve a real-world problem creatively.
2. Students will demonstrate the use of at least 2 simple machines in their prototype.
3. Students will describe Newton's Third Law as it impacted their design.

Narrative / Background Information

Prior Student Knowledge:
Students should be able to describe and provide examples of simple machines and their uses. Students should be able to state Newton's third law and provide real-world examples. Students should also be familiar with the engineering design process.

Science & Engineering Practices:
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design an object, tool, process, or system. (MS-PS2-1)

Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS-1-4)

Disciplinary Core Ideas:
ETS1.B: Developing Possible Solutions

- Models of all kinds are important for testing solutions. (MS-ETS-1-4)

PS2.A: Forces and Motions

- For any pair of interacting objects, the force exerted by the first object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law) (MS-PS2-1)

Crosscutting Concepts:
Systems and Systems Models

- Models can be used to represent systems and their interactions-such as inputs, processes, and outputs-and energy and matter flows within systems. (MS-PS2-1)

Influence of Science, Engineering, Technology and Applications of Science

- The uses of technologies and any limitations on their use are driven by individuals or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)

Possible Preconceptions/Misconceptions:

1. In Newton's third law, students may believe that equal force pairs cancel out resulting in no motion.
2. Simple machines decrease the amount of work being done.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:
Explain to students before watching the video that they are to WSQ (whisk)-Watch (take notes), Summarize (write a summary), Question (write 2-3 questions about the video). Show the video Real Life Robotics with Jasmine Lawrence. Allow students 2-3 minutes to write their summary and questions before sharing as a class.

Explain to students (if they have not identified) that Jasmine was an engineer from age 8, always solving problems that impacted her directly before moving into careers where she impacts the lives of others.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:
Prior to the lesson gather the following material(s):

- *A Crash Course in Forces and Motion with Max Axiom* by Emily Sohn (optional interdisciplinary activity)

Ask students to brainstorm what they think might be an issue faced by their grandparents or a person with limited mobility and list them all. Ask students to identify the problems that can be addressed by design.

(Optional Activity: Read aloud *A Crash Course in Forces and Motion with Max Axiom* pages 4-17, this selection discusses forces and motion. Students choose an amusement park ride and write a few sentences explaining one of the laws of motion that makes the ride work and identify the simple machines found in the design of the ride. Ask students to share their descriptions. This is an opportunity to refresh students' minds about the everyday uses of simple machines and the laws of motion. It's a great place to address any misconceptions- simple machines make work easier by changing the size/direction of the force and in terms of the 3rd law of motion, forces don't cancel but act on a different object.)

Now ask students to create their own engineering team of four (4) to create a solution to one of the problems that was identified as having a design solution.

EXPLAIN: Concepts Explained and Vocabulary Defined:
Teacher will explain the design process. Define the design process as a series of steps that guides engineering teams to solve problems. The steps are 1) identify a need/problem, 2) research the problem, 3) sketch possible solutions/designs, 4) select the best solution/design, 5) make a model/prototype of solution, 6) test and evaluate the effectiveness of the solution/design, 7) communicate findings and reflections, and 8) redesign the solution based on the evaluation and reflections.

Vocabulary: design process- a series of steps that guides engineering teams to solve problems

ELABORATE: Applications and Extensions:
Prior to starting the elaboration section of this lesson, you will need to gather the following materials:

- Cardboard
- String or flexible wire (like pipe cleaners)
- Plastic bottles
- Dowels (various sizes)
- Scissors
- Tape
- Glue
- Marbles (for testing prototypes)

First ensure each team has selected a problem that has a design solution. Once the team has recorded the problem, allow 5-10 mins to research the problem online (you may want to have a folder with specific websites). Tell students to independently sketch their design solution(s) for 5-8 mins before meeting as a team to discuss and select the best design solution. Once teams have selected their design solution, they should begin creating the prototype which includes a simple machine and test it 3 times before writing their presentation.

EVALUATE:

Formative Monitoring (Questioning / Discussion): Students demonstrate their working prototype, explaining how the laws of motions and the simple machines work to solve the problem. (The test could be transporting marble(s) from one point to another either vertically, horizontally, or both)

Summative Assessment (Quiz Project / Report): Written Design Process report including the redesign ideas.

Elaborate Further / Reflect: Enrichment: Redesign the device and test the improvements.

SOCIAL EMOTIONAL LEARNING ACTIVITY

Relationship Skills
When Jasmine Lawrence shares her top takeaway she says, "Our job is to love people" (53:21). The ability to establish and maintain healthy and supportive relationships requires work and practice. Students need time to practice communicating effectively, working in teams, standing up for each other and seeking support and help when needed. Here are two activities that support the development of positive relationships.
First activity is called **Fishing for Compliments**. This is an opportunity for students to reflect on their interactions with peers and write something nice about them/give a compliment. All you need is a sheet of paper with each student's name on it, then pass the paper around the class. When students receive the page, they provide a compliment (*a polite statement of praise or admiration*). Once the sheets of paper have circulated to at least 10 students, collect them (you may want to read over them before) then return to the student's whose name is on top to read through.
The second activity is called **Overcoming Problems- Breakthrough not Breakdown**. With this activity students practice seeking support and

helping when needed. Explain to students that problems can often seem hard to solve, for some people it's like facing a brick wall. Ask students, without taking the problem on, what problems could they help solve and who would they be able to help. Students create a list of the names of the people they believe they could help and the problem they would help remove. Then students share privately with the individual they can help or students, without saying the names, share the kinds of problems that need solving. If sharing as a whole class, students should make broad statements, like making new friends, studying for math tests, or talking with adults/teachers.

INTERDISCIPLINARY CONNECTIONS/IDEAS

English Language Arts: Students use the graphic novel, A *Crash Course in Forces and Motion with Max Axiom* by Emily Sohn and cite specific textual evidence to support the analysis of the laws of motion in amusement park rides. (See optional activity)
During this lesson, students conduct a short research project to answer a question using multiple sources which aligns with Common Core Standard WHST.6-8.7

Materials Required for This Lesson/Activity	
Quantity	**Description**
Per student	Laptops
	Cardboard (collected from staff and students)
Per team of 4	Scissors
Per team of 4	Glue
2 m per team	String
4 per team	Pipe cleaners
4 per team	Dowels
2 rolls per class	Tape
	Plastic bottles (collected from staff and students)
	A *Crash Course in Forces and Motion with Max Axiom* by Emily Sohn

Lesson Created by Stacy Douglass
For questions, please contact info@usasciencefestival.org