### What’s our process?

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<th>Middle School</th>
<th>Standard(s): MS-ETS-1-1 through MS-ETS1-4; CSS-ELA.SL1,4,5,6</th>
<th>Topic: What’s our process? Engineering Design Process</th>
<th>Developed by: ASNE with videos from NASA</th>
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**Overview:** Students will first design their own engineering process (15-20 minutes) and then look at NASA videos that describe an engineering process. There are 6 videos describing one step in NASA’s engineering process (each one is between 1 and 2 minutes long, so a total of 15-250 minutes). Students will discuss each video and will close by adopting an engineering design process they will use in future design sessions (5-30 minutes).

**Prior Student Knowledge Required:**
- None

**Student Learning Objective:**
A. Understand the six stages of this engineering design model.
B. Use this engineering design model to plan and execute engineering future engineering tasks.

**Materials:**
- Technology to play YouTube video
- Place for students to record thoughts (notebook/pencil, chalkboard/chalk, poster/art supplies, etc.)
- Permanent place to record your engineering design process (poster, webpage, PowerPoint slide, etc.)
- Access to FLEET Forums to store and share your engineering design plan.

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**LESSON PLAN – (This uses the 5-E Model)**

**Engage**

1. Students will make an engineering plan in this lesson. Use a big engineering task to spark student’s imagination. You can choose one below or highlight a problem that is local or timely:
   
a. The U.S. government paid $13 billion for the most recent aircraft carrier, the **USS Gerald Ford**. Describe your plan to create an aircraft carrier that could earn you $13 billion!

b. Sometimes ships have to go across the Arctic Ocean through the ice. They use ice breakers like the Coast Guard Cutter **Healy**. Create a plan to build a new and improved icebreaker that can travel across the Arctic Ocean.

c. A local marine biologist wants to explore dolphins that usually swim a couple miles off the coast. She wants to have a glass-bottom boat so that she can watch the dolphins swim and interact. Create a plan that will convince her that you can build the perfect glass-bottom boat for dolphin watching (You may choose to play this glass-bottom boat video on mute while students work: [https://www.youtube.com/watch?v=XKAUlzoT3WM](https://www.youtube.com/watch?v=XKAUlzoT3WM)).

d. Imagine NASA will pay someone $25 million to create a machine to gather rocks on Mars. Create a plan that shows you would get the job done.

e. There were no bridges over the Mississippi River until 1856 ([literary resource](https://www.literary-resource.com)). Using tools and materials available in the 1850s, create a plan to build the first bridge across the Mississippi River.

2. These problems are case studies. Groups of students will create a plan to address an engineering problem. This will engage students in a design process and these experiences will be the heart of the final conversation (Step #15).

3. As you group students together, remind them that most engineers work in teams and cooperate closely together. Before letting students work on the problem, remind them one last time that they are designing the process to solve the problem, they are not directly solving the problem yet.

**Explore**

4. Give students 15-20 minutes to create a process. If any groups stop working before the time is done, ask them to improve the process.
### What's our process?

5. Have each group share the results. If there is some consensus, then list everyone’s ideas together. If there are very divergent processes, list them next to each other in a way that everyone can see.

### Explain

6. Conclude the sharing session with a couple similarities and differences in the results. Also reflect on how students work together. They were designing a process, so they already engaged in a type of engineering design process.

### Explore

7. NASA released a series of videos that use 6 simple words to describe a basic engineering design process:
   - a. **Ask** questions
   - b. **Imagine** solutions
   - c. **Plan** possible designs
   - d. **Create** models
   - e. **Experiment** and try out the model
   - f. **Improve** the model by revising it

8. There are six videos (one for each engineering design process) below. After each video, ask if they have any questions and then ask them the discussion questions provided.

9. **Ask**
   - a. Link: [https://youtu.be/Oy1DrYTfwi](https://youtu.be/Oy1DrYTfwi) (Length: 1:51)
   - b. Class Discussion Questions:
     - i. What engineering question(s) is asked in this video? (how to build a rocket, and lots of sub questions)
     - ii. What does “ask” mean to an engineer? (clarifying the problem)
     - iii. What is a condition in finding a solution? ()
     - iv. What is a limitation in finding a solution? (what are things we want to use but don’t have infinite amount of)

10. **Imagine**
    - b. Class Discussion Questions:
       - i. What is the “spirit of imaging”? (having a wide range of possible solutions)
       - ii. What does it mean that ideas “synergistic”?
       - iii. What does it mean that ideas “build on each other”? (you may hear someone’s idea and add something to it to make it better)
       - iv. What does it mean that “there are no bad ideas”? (we need to come up with many different ideas that are wildly different)

11. **Planning**
    - b. Class Discussion Questions:
       - i. Why do we plan? (because time and other resources are limited)
       - ii. How does the video suggest you plan? (sketching)
       - iii. Do you agree that is the best way for you and your group to plan? (no correct response here)
What's our process?

iv. What do you change during the experiment phase? (one variable)
v. What is a test of a sketch? What makes it a “good” sketch? (You can draw something from it)

12. Creating
   a. Link: https://youtu.be/VzVjbGucZw8 (Length: 0:49)
   b. Class Discussion Questions:
      i. What is a limitation that you need to work in? (a certain amount of time)
      ii. What should you use from the Planning phase? (sketch)

13. Experiment
   a. Link: https://youtu.be/ICXihe66pfs (Length: 1:26)
   b. Literacy Question
      i. What does experimenting involve? (changing one variable)
      ii. What do you use to compare experiments? (data, measurements)

14. Improve
   a. Link: https://youtu.be/Kt1oVv2D_ns (Length: 1:22)
   b. Class Discussion Questions:
      i. What are questions that you should ask after the experiment? (What didn’t work? What could work better?)

Elaborate

15. Now bring the class together to discuss how the design plan in the video matched the design plans they created. How does this plan match the plans created in the student case studies? Are there steps in NASA’s design process that a group skipped? Is there a group that designed a process that does not fit into the NASA model?

16. There are lots of engineering design models so deviation is fine. NASA has a basic one that emphasizes creativity, testing, and iterative improvement.

17. Your end goal for this conversation could be one of the following:
   a. Adopting the NASA model as the process for your group going forward.
   b. Modifying the NASA model so that it incorporates any new ideas from the group.
   c. Creating a new model using the students’ language that encapsulates the ideas of being creative, testing and iteratively improving designs.

Evaluate

18. To test the new design process, have students reflect on the process they used to come up with their plan. Did they ask lots of questions? Did they test out each other’s ideas to see if they would reach the goal? Did they create a plan and then go back and improve it?
   a. This final conversation will help students become metacognitively aware when they are addressing engineering design principles in the future.

Bonus

19. If there is time, have a 10-15-minute conversation about what will make a good engineer. Look at the process you will use and come up with a list of behaviors and mindsets a person will need to work well on future engineering teams.
   a. The National Association of Engineers lists these 6 qualities: Systems Thinking, Creativity,
**What’s our process?**

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<th>Optimism, Collaboration, Communication, Attention to ethical considerations</th>
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<td><strong>b.</strong> Your list can differ, but it would be best to keep the list between 4 and 8 so it is easy to remember.</td>
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<td><strong>c.</strong> These qualities may help you address off-task behavior and help groups work together better.</td>
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### Additional Resources

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<td><strong>A.</strong> Throughout your teaching, please use the FLEET Forum called “FLEET Discussion” as a place to share what works and what you had trouble with (<a href="http://www.navalengineers.org/Membership/Forum">http://www.navalengineers.org/Membership/Forum</a>). Also, feel free to use that space to list your ideas as a safe space to try out ideas amongst other educators thinking about the same issues.</td>
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<td><strong>B.</strong> NASA also has an educator-facing overview video of this process (2:45): <a href="https://www.youtube.com/watch?v=c0wh4GxoL28&amp;list=PLiuUQ9asub3TqAiPRqhOjudMTPeMzwPtL&amp;index=6">https://www.youtube.com/watch?v=c0wh4GxoL28&amp;list=PLiuUQ9asub3TqAiPRqhOjudMTPeMzwPtL&amp;index=6</a></td>
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<td><strong>C.</strong> The Massachusetts Department of Education has a great design process (link below). ASNE has created a handout of their engineering process description along with ELA questions. <a href="http://www.doe.mass.edu/frameworks/scitech/2016-04.pdf#page=110">http://www.doe.mass.edu/frameworks/scitech/2016-04.pdf#page=110</a></td>
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<td><strong>D.</strong> If you are interested in a survey of different engineering design principles, see this article published by NASA and Texas researchers: <a href="https://www.asee.org/public/conferences/8/papers/4130/view">https://www.asee.org/public/conferences/8/papers/4130/view</a></td>
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