SeaGlide_TEAM	Create	Lesson #6 (60 minutes)

Description:

Students will focus on the *Create* portion of the engineering design process which includes prototyping. They will continue their roles as Civil Engineers as well as continue to work on their Bridge Design projects. This is the fifth lesson of the six lesson unit project. Students will construct a prototype based on their technical drawings. Students' primary focus is to construct and complete their final prototype of their bridge designs. After completion, their models should be stored to test and analyze in the next lesson.

Students will be able to:

- Define prototyping
- Use the engineering design process to construct a model
- Keep a record of their building process using their engineering notebook

Students will understand:

The *Create* portion of the engineering design process involves the construction of a prototype. This part of the engineering design process is important because it allows engineers to test and receive feedback on their solution. Students will create a final prototype to create a three-dimensional representation of their bridge designs. Students will store their completed prototypes for later testing and analyzation.

Key Definitions & Concepts: [1]

- **Prototype**: an early model of a product built to test a concept or process; to act as model on which something is patterned.

Standards: [Copied from: 2]

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

	Background Information	

Prior Knowledge:

- The Engineering Design Process
- Logical thinking
- Organizational techniques
- Measuring and scaling techniques

Science Practices: [Copied from: 3]	**Core Ideas: [Copied from: 4]**	**Cross Cutting Concepts: [Copied from: 5]**
● Developing and Using Models ● Analyzing and Interpreting Data ● Constructing Explanations and Designing Solutions ● Obtaining, Evaluating, and Communicating Information	● Developing Possible Solutions ● Optimizing the Design Solution	● Cause and Effect ● Systems and System Models ● Structure and Functions ● Stability and Change

Possible Preconceptions/Misconceptions:

Since this lesson is an extension of the engineering design process, students should be able to complete this lesson successfully. This lesson is designed in a way to help students thoroughly understand any associated concepts through discussion. This lesson allows students to have creative freedom and the ability to make decisions independently. There should be no outstanding misconceptions with these topics.

Lesson Plan - 5E(+) Model

Engage:

The instructor will hand out the *Engineering Design Process: Plan Review* pre-quiz for students to complete individually and turn in for grading. This pre-quiz will have students answer a series of short questions designed as a review of the material covered in the previous lesson. The purpose of this pre-quiz is to have students review and recall the material pertaining to the *Plan* step of the engineering design process. The goal is to have students show that they have full understanding of this portion of the engineering design process. This section should take 5 minutes to complete.

Explore:

Part I: Introduction: [6]

The instructor will hand out the *Engineering Design Process: Prototyping* handout. Students will get into their Bridge Design project groups. The instructor will quickly go over the directions of the building process and distribute the materials that will be used to the construction of their prototypes as well as their engineering design binders. The purpose of the this handout is to have students understand the end goal and to allow for the instructor to address any questions that students may have. This section should take about 5 minutes to complete.

Part II + III: *Benchmark and Investigation Lesson*: Constructing a Prototype

The benchmark and investigation portion of this lesson will be combined to allow students to use their technical drawings to construct their prototypes. Students should be expected to replicate the dimension and geometry of their sketches. Students should keep record of their building process and

any complications that may have occurred throughout constructing their prototype. This should include, but not be limited, to thought processes, challenges faced, how those challenges were resolved, and successes. Students can reference both the instruction sheet and their technical drawings to best replicate their design. Encourage students to take turns building and recording between their group members as well as work on the construction of a different part of their bridge while another part dries. The purpose of the build is to have students construct a tangible, visual representation of their bridge design. The purpose of the recording process is to allow students to keep record of their process in order for evaluation in the following lesson. This is an essential part of the engineering design process, as it minimizes repetition of mistakes. Students will learn how about the transition from idea to product and the challenges faced throughout that process. The goals and expectations of this project can be found on the attached rubric titled, *Bridge Design Project Rubric*. This section should take 45 minutes to complete.

Explain:

Throughout the exploration, students will engage in discussions that inquire their understanding and knowledge of the information at hand. Instructors will be informally asking students to explain their solutions and thought process throughout the entirety of the lesson. The worksheets in the engage portion of the lesson will ask questions that will require students to engage in higher level thinking, allowing them to verbalize and self-assess their understanding of the material.

Elaborate:

The elaboration of this lesson are the benchmark and investigation sections. Civil Engineering is a career path that involves a wide range of skill sets and works within the environment, construction, transportation, and several other areas that impact everyday life. The engineering design process lays the foundation for all engineering based projects and designs. Constructing a prototype is an essential part of that process. The student-led exploration activity allows the students to gain the mindset of an engineer by dissecting a real-world scenario.

Evaluate:

This lesson is designed to have both informal and formal evaluations throughout its entirety. The informal evaluations occur throughout the exploration because of the guiding open-ended questions. This allows the instructor to gauge surface-level student understanding. This also is done through listening to student conversations and by observing how students work through the build and record process. During this time, the instructor has the ability to hear and address any misconceptions or misunderstandings as necessary. The formal evaluation of this lesson is the engage pre-quiz and the exit ticket. The exit ticket is a 5 minute, individual activity which has the students self-assess their work and use what they have learned throughout the lesson and previous lessons to draw conclusions on their performance and finished design product. The purpose of the exit ticket is to have students show they have full understanding of the main topics of the lesson.

Enrich:

The lesson could be differentiated by having students create an advanced three-dimensional technical drawing of an object. Students could also go into further depth on the different standards required for technical drawings such as: dimensions, sectioning, views, projections, etc. For example, students could create a multiview drawing of an object and transfer that design onto the CAD software. Another example is to have students create the technical drawing by hand and have a different student replicate that design on the CAD software. These types of assessments are commonly seen in college-level engineering courses and can be carried into real-world careers that work in virtual, three-dimensional modeling. Hence, this lesson can be differentiated into a college-level engineering course as a beginning-term freshman project.

All associated documents are attached below

Reference *Annotated Bibliography* on the very last page of this packet

Name: _____ Date: _____

Engineering Design Process: *Plan* Review

1. Explain what technical drawings are used for and state one reason why they are important.

2. You are in the process of designing a new microchip and are on the *Plan* step of the engineering design process. When creating a sketch of your design, what type of scaling will you use?
    a. A scaled up drawing
    b. A scaled down drawing
    c. A sketch that is the same size as the actual microchip

3. What are the two methods used for producing a technical drawing?
    a. Manual drawing and CAD software
    b. Manual drawing and Photoshop
    c. Manual drawing and Microsoft paint

4. When designing a bridge to have high resilience to extreme weather, the bridge can be any type (arch, beam, truss, etc.) as long as it is made out of steel. **Circle: True or False**

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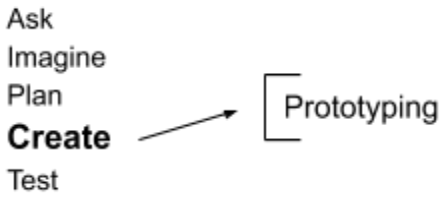
Name: _____ Date: _____
Engineering Partner Name: _____

Engineering Design Process: Prototyping [6-7]

Introduction: Prototyping is a major key step in the engineering design process. Imagine spending a significant amount of time and materials on a final product only to find that it does not work the way you intended. Engineers prototype as a means of saving time and funds that can be invested in producing the final product. Prototypes are usually made using materials that are different than the final version. This material tends to be cost friendly and easier to work with. Prototyping also allows for the engineer to test how the solution works and to receive feedback, allowing for further development of the structure, function, and appearance of their solution.

Engineering Design Process:



Directions: Today, you will continue your role as a Civil Engineer and focus on the *Create* portion of the engineering design process. During the past four lessons, your team has assessed the problem, conducted research, generated solutions, and conducted developmental work to create a bridge design that represents the precise intent of your team's solution. You will use your detailed blueprint to construct a final prototype of your bridge design. You will use cost effective material that is easy to work with. Use the *Things to keep in Mind* section below as a reference of useful tips that will your team to utilize your build time efficiently.

Materials:

- ~200 Popsicle Sticks (per group)
- 1 bottle of Wood Glue
- Clamps (binder clips work well)
- Sandpaper sheets (optional)

Things to Keep in Mind:

- The span of the bridge must be 30 in.
- Withstand (hold without collapsing) at least 25 lbs.
- Measure multiple times before you cut/glue your sticks
- Use minimal amount of glue to allow for faster drying time
- Keep record of your building process
- The glue dried best in a dry and warm environment (store should be low-humidity)

★ **Use the following sections to <u>record your building process</u> (this will help when you test and improve your bridge design).**

Use the space below to record your building process. Be sure to record your thought processes, any complications that may have occurred, how you plan to work through those challenges, and anything else that you feel is important to your building process.

Name: _____ Date: _____

Exit Ticket: Prototyping Self-Assessment

1. On a scale of 1 to 5 (1 being extremely unsuccessful and 5 being very successful), rate the success of your prototype building process. Explain your rating choice.

2. What specifications do you believe your design will meet? Which specifications does your design not meet? Explain why your design does not meet those specifications.

3. What are some changes you would make to your design? Why?

Name: _____ANSWER KEY_____ Date: _____

Engineering Design Process: *Plan* Review

1. Explain what technical drawings are used for and state one reason why they are important.

   Technical drawings used by engineers in order to communicate their design in a standardized manner. They are important because it captures all of the fine details a manufacturer may need.

2. You are in the process of designing a new microchip and are on the *Plan* step of the engineering design process. When creating a sketch of your design, what type of scaling will you uses?
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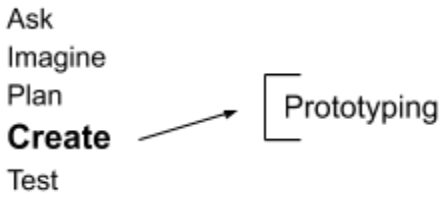

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**Student progress will vary with each group. Below is a list of things to look for when reviewing their building process notes:

- Their thought process (how they chose to tackle to build their prototype, where to start, etc.)
- Challenges faced and how they planned to work through those challenges
- Successes in their building process

Name: _____ANSWER KEY_____ Date: _____

Exit Ticket: Prototyping Self-Assessment

1. On a scale of 1 to 5 (1 being extremely unsuccessful and 5 being very successful), rate the success of your prototype building process. Explain your rating choice.

   Student responses will vary, focus on their explanation behind their rating (was it an honest rating?).

2. What specifications do you believe your design will meet? Which specifications does your design not meet? Explain how your design does not meet those specifications.

   Student responses will vary, focus on whether or not they explained why their design did not meet certain specification(s). The specifications are listed below

   Specifications:
   - Prototype must have a span of 30 in.
   - Prototype must withstand a weight of 25 lbs or more
   - Material that withstands earthquakes should be used
   - The structure and shape of the bridge should be able to withstand the vibrations of earthquakes
   - Bridge will be used for the public and have traffic flow

3. What are some changes you would make to your design? Why?

   Student responses will vary, focus on the reasoning behind why they would make those changes (did they learn from the mistakes made?).

Annotated Bibliography

[1] Dictionary by Merriam-Webster: America's most-trusted online dictionary. (n.d.). Retrieved from https://www.merriam-webster.com/

This website was used for adaptation within the Engineering Design Process: Create lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of providing definitions for the key concepts and definitions sections and for associated worksheets. The key concepts and definitions were adapted based on the grade and activities at-hand.

[2] Nsta. (n.d.). Access the Next Generation Science Standards by Topic. Retrieved from https://ngss.nsta.org/AccessStandardsByTopic.aspx

This website was used in each lesson in the Engineering Design Principles module to select proper national set standards for science subjects that each lesson is centered around.

[3] Nsta. (n.d.). Science and Engineering Practices. Retrieved from https://ngss.nsta.org/PracticesFull.aspx

This website used in every lesson in the Engineering Design Principles module to find Standards for Science and Engineering Practices that are applicable in each lesson.

[4] Nsta. (n.d.). Disciplinary Core Ideas. Retrieved from https://ngss.nsta.org/DisciplinaryCoreIdeasTop.aspx

This website was used in each lesson in the Engineering Design Principles module to select appropriate disciplinary core ideas set forth by the NSTA that are at the center of each lesson.

[5] Nsta. (n.d.). Crosscutting Concepts. Retrieved from https://ngss.nsta.org/CrosscuttingConceptsFull.aspx

This website was used in each lesson in the Engineering Design Principles module to selecting appropriate crosscutting concepts set forth by the NSTA that apply to each science lesson.

[6] Science Buddies. (2017). The Engineering Design Process: Prototyping. Retrieved from https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-prototypes

This website was used for research and content inspiration. This reference aided in the completion of analysis questioning. This reference was neither adapted nor excerpted.

[7] Instructables. (2017). Popsicle Stick Bridge. Retrieved from https://www.instructables.com/id/Popsicle-Stick-Bridge/

This website was used for adaptation purposes within the Engineering Design Process: Create lesson plan as a part of the Engineering Design Principles module. This reference aided in the completion of directions and materials for the *Engineering Design Process: Prototyping* handout through adaptation.