SeaGlide_TEAM	Ask	Lesson #3 (60 minutes)

Description:

Students will dig deeper into the *Ask* portion of the engineering design process which is broken down into three major steps: identify the problem, specify requirements, and conduct background research. They will continue their roles as Civil Engineers and be introduced to the Bridge Design project, which involves the construction of a bridge prototype using the engineering design process. This lesson is the second lesson of a six lesson unit project. Students will be presented with a project proposal letter that initiates the scenario in which their bridge design will be based on. Students will have to formulate a problem statement, identify constraints, and conduct background research based on what was given in the project proposal. Their work will later be added to their engineering design binders to help keep their bridge design notes accessible for reference.

Students will be able to:

- Define the steps that make up the *Ask* of the engineering design process
- Conduct research on a given topic
- Use the engineering design process to assess a problem and its constraints
- Identify the different types of bridges
- Explain how load and forces affect the structure of a bridge

Students will understand:

The *Ask* portion of the engineering design process involves problem assessment and extensive solution research. This part of the engineering design process is important because it sets the foundation for the rest of the design and build process. Students will conduct research in order to gather information that they will later use in their bridge design.

Key Definitions & Concepts: [1]

- **Constraints**: anything that imposes restriction, limitations, or hinders someone or something involved in the completion of the project.
- **Natural Disasters**: a sudden event in nature (such as a hurricane, tornado, or flood) that commonly results in serious damage or loss of life.
- **Project Proposal**: a document that describes the plan or intention of a project.
- **Research**: the systematic investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws.

Standards: [Copied from: 2]

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal need and wants.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Background Information

Prior Knowledge:

- Organizational techniques
- The Engineering Design Process
- Logical thinking

Science Practices: [Copied from: 3]	**Core Ideas: [Copied from: 4]**	**Cross Cutting Concepts: [Copied from: 5]**
● Asking Questions and Defining Problems ● Planning and carrying out investigations ● Analyzing and Interpreting Data ● Engaging in Argument from Evidence ● Obtaining, Evaluating, and Communicating Information	● Defining and Delimiting Engineering Problems	● Patterns ● Cause and Effect ● Structure and Function ● Stability and Change ● Influence of Science, Engineering, and Technology on Society and the Natural World

Possible Preconceptions/Misconceptions:

A possible misconception that may occur is the use of credible sources during the investigation portion of the exploration that involves conducting background research. Since this lesson does not explicitly discuss credible sources, expect students to have difficulty pulling information from credible websites and expect to provide students with a basic understanding of what sources may or may not be considered credible.

Lesson Plan - 5E(+) Model

Engage:

The instructor will hand out the *Engineering Design Process Review* pre-quiz. This pre-quiz will have students answer a series of questions that is designed as a review of the material covered in the previous lesson and that includes an overview of the engineering design process and the engineering notebook. The purpose of this pre-quiz is to have students recall what they learned in the previous lesson. The goal is to have students refresh their understanding of the engineering design process and the engineering notebook in order to be prepared for the activities in the current lesson. This section should take 5 minutes to complete.

Explore:

Part I: Introduction:

Building on the pre-quiz given in the engage portion of the lesson, the instructor will hold a brief discussion by verbally reviewing and correcting the students' pre-quiz. The focus of the discussion is to make sure students have refreshed their memory of the process they went through when conducting their investigations and how the engineering design process was implemented. This will carry students into the next activity, where they will be introduced into the Bridge Design Project. They will go into further depth on the steps of the engineering design process one step at a time to build a prototype of a bridge over the course of the next four lessons. The goal of this section to have students understand the overall end goal of the bridge project. The goals and expectations of this project can be found on the attached rubric titled, *Bridge Design Project Rubric*. This time could also be used to address any questions and clarify any concerns that students may have. Students should also begin preparing engineering design notebooks/binders where they can add pages of their engineering design process throughout the duration of their bridge project. These pages include worksheets associated with their explore activities and any other documents that will aid in their design process. The pages can be added once they have been graded by the instructor. This section should take less than 10 minutes to complete, depending on how many questions are asked.

Part II: *Benchmark Lesson*: Identifying Information [6]

Students will move onto the *Bridge Design Project: Identifying the Need and Conducting Background Research* worksheet, where they will be focusing on the *Ask* portion of the engineering design process. Students will work in pairs (these groups will remain the same for the duration of the project) and take on the role of Civil Engineers to create a problem statement, identify requirements, and conduct background research associated with their bridge design process. Students will first read through their project proposal and identify what needs to be fixed and why the problem exists so that they can create their problem statement. This will follow a specific format which is also listed in the worksheet. Students will then read through the proposal a second time and list the requirements that their bridge must meet as well as any constraints to look out for. The goals and expectations of this project can be found on the attached rubric titled, *Bridge Design Project Rubric*. The purpose of this activity is to have students be able to look through given information and identify the key information needed, as well as break down what they are reading into more understandable parts. This section should take about 15 minutes to complete.

Part III: *Investigation Lesson*: Conducting Background Research

Students will continue to work in their groups and move on to the bulk of the exploration, which involves conducting background research. Now that they have identified the problem that they are tackling and the requirements that they need to meet, students will conduct research on pre-existing bridges and the different factors that should be considered when designing a bridge. Students will follow the guided questions in order to help conduct proper research and make sure they are obtaining all of the necessary information. The purpose of this activity is to have students conduct independent research and gather information from several online sources. Students will have freedom in the format of their obtained information and should also be encouraged to include sketches to help with their explanations. This section should take 25 minutes to complete.

Explain:

Throughout the exploration, the 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 research and relevant connections throughout the entirety of this lesson. The worksheets will ask questions that will require students to engage in high-level thinking, allowing them to verbalize and self-assess their understanding of the material. The investigation portion of the exploration activity is designed in a way where each student is providing their own explanation. This allows for individuality between each students' responses and explanations. This also allows for the instructor to have a better means of gauging what each student is understanding based on their response.

Elaborate:

The elaboration portion of this lesson is covered through the investigation lesson where students conduct meaningful research as Civil Engineers. Civil Engineering is a career path that involves a wide range of skill sets and that works within the environment, construction, transportation, and several other areas that impact everyday life. Recall that the scientific method lays the foundation for all scientific based research and experiments; similarly, the engineering design process lays the foundation for all engineering based projects and designs. Hence, problem assessment and conducting research are essential parts 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 leading, open-ended questions and class discussions. This allows the instructor to gauge surface-level student understanding. This is done through listening to student conversations and observing how students work through the activity worksheets. 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 that has the student assess what they learned throughout the entirety of the lesson to show that they have full understanding of the lesson objectives.

Enrich:

This lesson could be extended by having students investigate environmental issues and research ways in which robotics can be implemented to help work towards the solution of these issues. Since the engineering design process is best learned by using problem-based learning, students have the opportunity to address real-world problems around them to understand the importance of each step of the engineering design process. Conducting proper research allows for better understanding of the issue at hand and prepares the students to be prepared to work towards a solution as efficiently as possible. Hence, this lesson can be differentiated into an environmental studies class or into a college-level engineering class 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 Review

1. The engineering design process is…
    a. A linear process with a beginning and an end
    b. An iterative process
    c. A theory
    d. A quick process
2. Number the steps of the engineering design process in order from 1 through 5:
    ____ Create: build a prototype
    ____ Plan: design a solution
    ____ Imagine: develop a possible solution
    ____ Ask: define the problem, background research, specify requirements
    ____ Test and Improve: test the design, evaluate the solutions
3. What are engineering notebooks used for?

Name: _____ Date: _____

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3. What are engineering notebooks used for?

City of Chestnut Ridge
Office of City Council
2300 Raton Rd • P.O. BOX 1564
Chestnut Ridge, Washington 20003

Request for Proposal: Civil Engineering Services

The Department of Public Works and Facilities under the Federal Highway Bridge Program proposes to replace the existing narrow, 65 year old bridge over Dal River. The current bridge was constructed using poor material that does not withstand against natural forces. Due to recurring earthquakes, the foundation of the bridge has developed cracks along its foundation. The proposed project will improve the overall structure of the bridge to withstand natural forces and will provide a roadway for traffic flow.

The City Council is seeking services from a qualified civil engineer to perform design work, plan preparation, and define specifications for a new bridge.

To submit a proposal, you must provide a completed design brief that includes the following:

- Background research
- Specifications
- Brainstormed ideas and solutions
- Detailed bridge sketches
- Final prototype

The proposed bridge prototype must meet these specifications:

- Span: 30 in. (to represent a 1:50 ratio, given that the bridge has a span of 1500 ft.)
- Must withstand a weight of at least 25 lbs.

Sincerely,

Melissa Myja

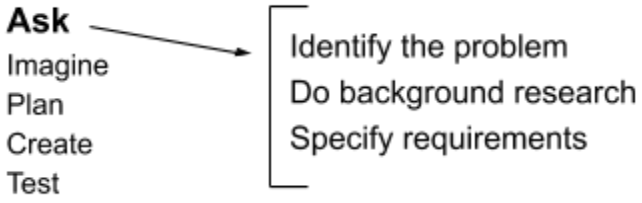
Melissa A. Myja
City Council President

Name: _____ Date: _____
Engineering Partner Name: _____

Bridge Design Project: Identifying Information and Conducting Background Research [6]

Introduction: When an engineer starts a new project, it is important for them to understand what it is that they are solving. This process includes identifying the needs of the people involved, researching existing solutions, and investigating how the product is intended to work which includes the design requirements needed to successfully complete the project. You will take on the role of a Civil Engineer, and you have received a letter from the city council of Chestnut Ridge stating a project proposal for a new bridge design. You will implement all of the skills you have acquired through investigating the engineering design process and design a safe and functional bridge that can replace the current bridge.

Engineering Design Process:



Directions: Today, you will focus on the *Ask* portion of the engineering design process. You will implement the engineering design process and create a problem statement by identifying the finished result you will be working towards. You will also list any requirements that you need to take into consideration when working on your project. Then you will conduct in-depth background research on your project. Make sure to use credible sources.

Problem Statement: Identify the problem you are solving. **(**Remember to use the format [WHO] needs [WHAT] because [WHY]):
Constraints: List any specifications or restrictions associated with your project.

Background Research:

What are some of the different types of bridges that exist? List their pros and cons.

How do loads and forces (such as tension and compression) affect the structure of a bridge? (Using sketches may be helpful to visualize the load distribution.)

What are some environmental considerations (natural disasters) that should be considered when designing the bridge? How to they affect the bridge? How can the bridge be designed to withstand these impacts?

What are the different types of materials used to construct a bridge? How durable are they? How do different weather types affect these materials?

Name: _____ Date: _____

Exit Ticket: Engineering Design Process - Ask

1. In what format should the problem statement be written?
    a. WHO needs WHAT by WHEN?
    b. WHO needs WHICH for HOW?
    c. WHO needs WHAT because WHY?
    d. WHO needs WHICH because WHY?

2. What are the three steps that make up the “Ask” of the Engineering Design Process?

3. Which of the following statements best describes the term “constraints”?
    a. Constraints involve the process of identifying the needs of the people involved.
    b. Constraints are the limitations of design including material restrictions and time limitations.
    c. Constraints are examples of prototypes.
    d. Constraints involves the research which is done to determine information that should be used when developing the design.

4. Explain how background research is conducted.

Name: _____ANSWER KEY_____ Date: _____

Engineering Design Process Review

1. The engineering design process is…
    a. A linear process with a beginning and an end
    b. An iterative process
    c. A theory
    d. A quick process

2. Number the steps of the engineering design process in order from 1 through 5:

    _4__ Create: build a prototype

    _5__ Test and Improve: test the design, evaluate the solutions

    _2__ Imagine: develop a possible solution

    _1__ Ask: define the problem, background research, specify requirements

    _3__ Plan: design a solution

3. What are engineering notebooks used for?

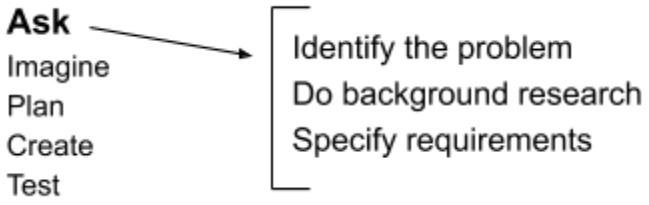
    Engineering notebooks are used to write down every observation, idea, drawing, question, answer, and other notes an engineering has during the course of their design process.

Name: _____ANSWER KEY_____ Date: _____
Engineering Partner Name: _____

Bridge Design Project: Identifying the Need and Conducting Background Research [6]

Introduction: When an engineer starts a new project, it is important for them to understand what it is that they are solving. This process includes identifying the needs of the people involved, researching existing solutions, and investigating how the product is intended to work which includes the design requirements needed to successfully complete the project. You will take on the role of a Civil Engineer, and you have received a letter from the city council of Chestnut Ridge stating a project proposal for a new bridge design. You will implement all of the skills you have acquired through investigating the engineering design process and design a safe and functional bridge that can replace the current bridge.

Engineering Design Process:



Directions: Today, you will focus on the *Ask* portion of the engineering design process. You will implement the engineering design process and create a problem statement by identifying the finished result you will be working towards. You will also list any requirements that you need to take into consideration when working on your project. Then you will conduct in-depth background research on your project. Make sure to use credible sources.

Problem Statement: Identify the problem you are solving.
(Remember to use the format [WHO] needs [WHAT] because [WHY]):

Anything along the lines of "The citizens of Chestnut Ridge need a new bridge because the current bridge is no longer safe due to the existing cracks along the foundation." (The statement should be in the *[WHO] needs [WHAT] because [WHY]* format).

Constraints: List any specifications or restrictions associated with your project.

- 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

Background Research:
What are some of the different types of bridges that exist? List their pros and cons.

- Suspension bridge:
    - Pros:
        - can span over long distances, inexpensive, easy to maintain
    - Cons:
        - vulnerable to wind and load limits

*Students should talk about how these bridges differ and give general facts about the bridge including recommend span and pros and cons. Above are some examples to look for.

- Cable-stayed bridge
- Arch bridge
- Truss bridge
- Beam bridge
- Cantilever bridge
- Drawbridge

How do loads and forces (such as tension and compression) affect the structure of a bridge? (Using sketches may be helpful to visualize the load distribution.)

- Force
- Loads
- Tension
- Compression

*Students should talk about how these different stress types affect the structure of the bridge; they should talk about how the load distribution is different for each bridge type.
*They are encouraged to include sketches to help with their explanations.

Examples:

Beam Bridge: Load is supported on the deck of the bridge by distributing tension and compression evenly which allows it to be squeezed and stretched.

Arch bridge: load is supported by distributing compression across and down the arch.

What are some environmental considerations (natural disasters) that should be considered when designing the bridge? How to they affect the bridge? How can the bridge be designed to withstand these impacts?

- Floods - pick up debris (trees, cars, etc) and push them forcefully against the bridge
    - Structure breaks and washes away
- Earthquakes - bridge sways and columns flex causing the structure to become weaker
    - Bridge can be built using lighter and flexible material that ridge in the right place
        - Will flex during the earthquake but snap back in place and minimize structural damage
- Hurricanes - waves can significantly damage or destroy a bridge
    - Bridge can be built higher so the waves don't hit the bridge

*This section is a bit more tricky for students to research, but listing information about earthquakes could be sufficient. Above are some examples of what to look for.

What are the different types of materials used to construct a bridge? How durable are they? How do different weather types affect these materials? List the advantages and disadvantages.

- Steel
    - Advantages:
        - Very strong
        - Very durable in tension and compression
        - Assembles quickly
    - Disadvantages:
        - Expensive
        - Can rust which reduces strength
        - Not recommended for beam bridges
- Concrete
    - Advantages:
        - Extremely strong in compression
        - Less expensive than steel
        - Very malleable
    - Disadvantages:
        - Brittle material, prone to crack
        - Weak in tension forces
        - Don't gain full strength until much time has passed

*Students should talk about the different materials not only limited to steel and concrete. They should also list force interactions, weather impacts, etc. Above are some examples to look for.

Name: _____ANSWER KEY_____ Date: _____

Exit Ticket: Engineering Design Process - Ask

1. In what format should the problem statement be written?
    a. WHO needs WHAT by WHEN?
    b. WHO needs WHICH for HOW?
    c. WHO needs WHAT because WHY?
    d. WHO needs WHICH because WHY?

2. What are the three steps that make up the “Ask” of the Engineering Design Process?

    1. Define the problem
    2. Specify Requirements/Constraints
    3. Do background research

3. Which of the following statements best describes the term “constraints”?
    a. Constraints involve the process of identifying the needs of the people involved.
    b. Constraints are the limitations of design including material restrictions and time limitations.
    c. Constraints are examples of prototypes.
    d. Constraints involves the research which is done to determine information that should be used when developing the design.

4. Explain how background research is conducted.

    Background research is conducted by determining which products are viable and that already exist, by determining information that should be used when developing the design, and by researching how the product(s) should work and how to make it work for the given scenario.

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: Ask 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: Define the Problem. Retrieved from https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-problem-statement

This website was used for adaptation and excerption purposes within the Engineering Design Process: Ask lesson as a part of the Engineering Design Principles module. This reference aided in the completion of analysis questioning; the format of the problem statement, constraints, and background research were excerpted and adapted.