SeaGlide_TEAM	Imagine	Lesson #4 (60 minutes)

Description:

Students will implement the steps within the *Imagine* portion of the engineering design process which is broken down into two major steps: brainstorming solutions and choosing the best solution. They will continue their roles as Civil Engineers as well as continue to work on their Bridge Design projects. This lesson is the third lesson of the six lesson unit project. Students will use the information gathered in the previous lesson to brainstorm multiple solutions for their bridge prototype. Students will decide which one of their ideas is the best fit for their bridge projects based on the requirements it fulfills. After completion and grading, their work will be added to their engineering design binders to be accessible for reference.

Students will be able to:

- Describe and apply the brainstorming guidelines
- Use brainstorming techniques to generate multiple alternate solutions
- Use rational thinking to choose the best solution
- Use evidence to support decisions

Students will understand:

The *Imagine* portion of the engineering design process involves brainstorming multiple solutions and evaluating ideas based on prioritized requirements. This part of the engineering design process is important because it allows for the implementation of prior research to work towards efficient solutions. Students will hold a brainstorming session to generate solutions for their bridge design. Students will then consider each proposed solution more carefully and decide which solution is the best fit for their design.

Key Definitions & Concepts: [1]

- **Brain-dump**: the act of comprehensively and uncritically expressing and recording one's thoughts and ideas about a particular topic to some storage medium (such as paper or a computer).
- **Brainstorm**: the process of coming up with new ideas very quickly to try to solve a problem before considering each idea more carefully.
- **Complementary**: combining in such a way as to mutually supply each other's lack or enhance the qualities of each other or another.
- **Food Engineering**: a specialized sub field within Agricultural Engineering which is focused on the applications of Engineering to the production and distribution of food [2].

Standards: [Copied from: 3]

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.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Background Information

Prior Knowledge:

- Organizational techniques
- Logical thinking
- The Engineering Design Process

Science Practices: [Copied from: 4]

- Developing and Using Models
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence

Core Ideas: [Copied from: 5]

- Defining and Delimiting Engineering Problems
- Developing Possible Solutions

Cross Cutting Concepts: [Copied from: 6]

- 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: Ask Review* pre-quiz. This pre-quiz will have students read through a scenario and prompt them to identify the different steps within the *Ask* portion of the engineering design process. Students should create a problem statement in the correct format, identify constraints, and define what they would conduct background research on and explain why. The purpose of this pre-quiz is to have students review and recall the material covered in the previous lesson. The goal is to have students use problem based learning to show that they have full understanding of this portion of the engineering process. The instructor should give the students 5 minutes to individually complete the pre-quiz then facilitate an open class discussion to review students' responses and address any misconceptions as necessary. This section should take up to 10 minutes to complete.

Explore:

Part I: Introduction: [7]

The instructor will propose a question along the lines of “Why do we brainstorm ideas?” This will encourage students to think about the importance of conducting brainstorming session and discuss what makes them effective. The purpose of this question is to have students understand why brainstorming sessions are commonly used as a strategy to generate new and creative ideas, which makes up the *Imagine* portion of the engineering design process. After a brief discussion, the instructor will distribute the *Brainstorming Guidelines* handout and review the things students should keep in mind while holding their brainstorming session. The instructor should prompt the students to read through and explain the importance behind each guideline point. Encourage the students to ask questions in order to clarify anything they may be unsure about. This section should take about 5 minutes to complete.

Part II: *Benchmark Lesson*: Brainstorming Solutions [8]

Students will get into their Bridge Design project groups, and the instructor will distribute the *Bridge Design Project: Brainstorming Solutions* activity worksheet as well as their engineering design binders. Using what they have researched and learned from the previous lesson, students will hold a brainstorming session in order to generate as many solutions as possible for their bridge design. Encourage students to be as creative as possible and use several different methods to get their ideas on paper as well as utilize all of their materials in their engineering design binder. Students should not go into depth with their ideas but, instead, come up with as many different solutions as possible. Students should hold discussions with their partner to verbally explain their thought process and build off of each other’s ideas. The purpose of this activity is to implement their conducted research and have students brain-dump their ideas all in one place. The goals and expectations of this project can be found on the attached rubric titled, *Bridge Design Project Rubric*. This section should take about 15 minutes to complete.

Part III: *Investigation Lesson*: Choosing the Best Solution [8]

Once each group has written down all of their ideas, students will transfer their ideas in list format and sort through their list to narrow down their solutions. Students will be given a few guided questions to help with the elimination process. Students will decide whether each idea satisfies the requirements they have listed in their activity worksheet of the previous lesson. If none of the solutions satisfy all of the requirements, students could either expand their listed solutions or brainstorm more solutions. Once the students decide on a solution that meets all of the requirements, they will explain why they have chosen that solution and in what ways does it meet all of the requirements. The purpose of this section is to understand what they are looking for and be be able to generate ideas that will fit what they wish their desired products to should look like. This section should take about 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 solutions and thought process 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.

Elaborate:

The elaboration of this lesson is the investigation lesson section. 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. The engineering design process lays the foundation for all engineering based projects and designs. Brainstorming and generating ideas 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 the 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 which has the students assess what they have learned throughout the entirety of the lesson by showing that they have full understanding of those topics.

Enrich:

This lesson could be extended by having students perform a project that involves researching the process of water filtration to produce clean water. Students can then hold a brainstorming session to generate new ideas to produce clean was at a lower cost in order to make clean water accessible to locations that currently do not have it. Conducting brainstorming sessions allows students to think about these real-world issues as something that could be worked towards a solution.

All associated documents are attached below

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

Name: _____ Date: _____

Engineering Design Process: *Ask* Review

Scenario: Jon is a Food Engineer and specializes in bubblegum. He has been hired by the Hubba Bubba company to design three new flavors for an upcoming annual Bubblegum Convention that is two months away. Hubba Bubba has requested that the flavors must be all new original flavors that have never been created before. During the flavoring process, at least 40% of the ingredients must be natural. The flavors must also be complementary flavors that people would actually enjoy. Finally, the shape of the bubble gum piece must represent its flavor.

Directions: Using the scenario above, answer the following questions:

1. Create a problem statement using the standard format?

2. List all of the criteria / constraints Jon must follow.

3. Explain what should Jon conduct background research on? Defend your answer.

Brainstorming Guidelines [7]

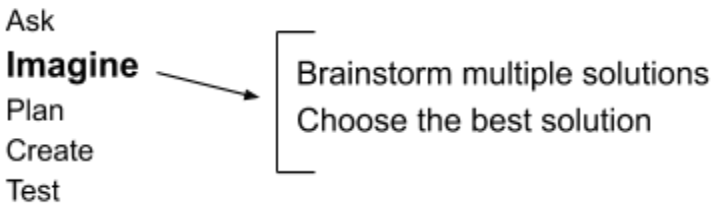
Withhold Criticism	● Refrain from criticizing the solutions of others and your own solutions
Focus on Quantity over Quality	● Capture as many solutions as you can
Encourage Weird / Wild Solutions	● Wild solutions usually lead to innovative designs
Record All Solutions	● Sentence structure, spelling and grammar don't matter for your list during your brainstorming session ● Wait until later to review or edit anything you write down ● What is important is capturing it all
Build on the Solutions of Others	● Combine and improve solutions ● Use previous solutions to generate
Stay Focused on the Topic	● Make sure you focus your solutions on the topic at hand

Name: _____ Date: _____
Engineering Partner Name: _____

Bridge Design Project: Brainstorming Solutions [8]

Introduction: In engineering, it is important to be able to generate multiple unique ideas. Engineers often use the brainstorming technique to help with the process of breaking out of the same thought pattern and developing a new way of viewing the problem. Brainstorming also serves as a great visual representation of all of the possible ideas and solutions. This technique often used by teams because it allows the mind of each individual to be tapped into in order to develop the most successful solution. This diversity of thoughts helps produce a better product.

Engineering Design Process:



Directions: Today, you will focus on the *Imagine* portion of the engineering design process. Your team has implemented the *Ask* of the engineering design process in order to better understand your project and the challenge you are tackling. You will hold a brainstorming session with your team in order to generate alternate solutions for your bridge design. Use the *Brainstorming Guidelines* handout to help you stay on track in order to generate a successful flow of ideas and solutions. You will then transfer your solutions into the *choosing the best solution* section and review your solutions in order narrow down your list by comparing your solutions to the constraints. If possible, select the best solution that your team feels best fulfills the requirements. If none of your brainstormed solutions meet the requirements, go back to the drawing board and brainstorm more solutions. Repeat this process until you have chosen the best solution.

Brainstorming Session: Follow the Brainstorming Guidelines handout to generate as many solutions as possible. Feel free to use different methods (e.g. lists, sketches, etc.).

Brainstorming solutions continued...

Choosing the Best Solution: Transfer your brainstormed solutions into a list here and narrow down your solutions. Use the following questions to help you in the narrowing process: How many requirements does it fulfill? Does it meet all the requirements? If not, can it be modified to meet all the requirements? If no solution meets all of the requirements, brainstorm more solutions.

Once you have chosen a solution that best fits all of the requirements, explain why you chose that solution and how it meets all of your requirements.

Name: _____ Date: _____

Exit Ticket: Engineering Design Process - Imagine

1. What are the steps within the *Imagine* portion of the engineering design process? List them.

2. What is the main focus of a brainstorming session?
    a. Quantity of solutions rather than quality
    b. Quality of solutions rather than quantity

3. What should you do if none of your solutions meet the requirements?
    a. Choose the solution that meets most of the requirements.
    b. Quit the project.
    c. Modify a solution until it meets all of the requirements or brainstorm more solutions

4. Which statement is **NOT** a part of the brainstorming guidelines?
    a. Stay focused on the topic
    b. Withhold criticism
    c. Encourage wild solutions
    d. Only record the solutions that make sense

Name: _____ Date: _____

Exit Ticket: Engineering Design Process - Imagine

1. What are the steps within the *Imagine* portion of the engineering design process? List them.

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    d. Only record the solutions that make sense

Name: _____ANSWER KEY_____ Date: _____

Engineering Design Process: *Ask* Review

Scenario: Jon is a Food Engineer and specializes in bubblegum. He has been hired by the Hubba Bubba company to design three new flavors for an upcoming annual Bubblegum Convention that is two months away. Hubba Bubba has requested that the flavors must be all new original flavors that have never been created before. During the flavoring process, at least 40% of the ingredients must be natural. The flavors must also be complementary flavors that people would actually enjoy. Finally, the shape of the bubble gum piece must represent its flavor.

Directions: Using the scenario above, answer the following questions:

1. Create a problem statement using the format?

   Hubba Bubba needs 3 new original bubblegum flavors for an upcoming annual Bubblegum Convention.

2. List all of the criteria / constraints Jon must follow.

   - 2 month deadline
   - Flavors must be original and never used before
   - 50% of flavoring ingredients must be natural
   - Flavors must be complementary
   - Must include flavors the general public would enjoy

3. Explain what should Jon conduct background research on? Defend your answer.

   Jon should conduct background research on the different types of bubble gum flavors available in the market, past surveys that were conducted to test the most desirable flavors, the different types of natural ingredients used for flavoring and how they would affect the texture of gum, and different methods to produce gum shapes.

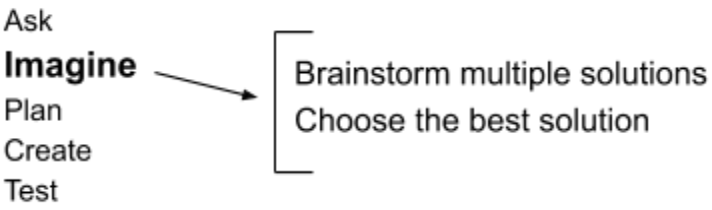
   **Student responses may vary but should be accepted as long as they touch on at least 3 of the constraints and they provide evidence to support their answers.

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

Bridge Design Project: Brainstorming Solutions [8]

Introduction: In engineering, it is important to be able to generate multiple unique ideas. Engineers often use the brainstorming technique to help with the process of breaking out of the same thought pattern and developing a new way of viewing the problem. Brainstorming also serves as a great visual representation of all of the possible ideas and solutions. This technique often used by teams because it allows the mind of each individual to be tapped into in order to develop the most successful solution. This diversity of thoughts helps produce a better product.

Engineering Design Process:



Directions: Today, you will focus on the *Imagine* portion of the engineering design process. You and your teams have implemented the *Ask* of the engineering design process in order to better understand your project and the challenge you are tackling. You will hold a brainstorming session with your team in order to generate alternate solutions for your bridge design. Use the *Brainstorming Guidelines* handout to help you stay on track in order to generate a successful flow of ideas and solutions. You will then transfer your solutions into the *choosing the best solution* section and review your solutions in order narrow down your list by comparing your solutions to the constraints. If possible, select the best solution that your team feels best fulfills the requirements. If none of your brainstormed solutions meet the requirements, go back to the drawing board and brainstorm more solutions. Repeat this process until you have chosen the best solution.

Brainstorming Session: Follow the Brainstorming Guidelines handout to generate as many solutions as possible. Feel free to use different methods (e.g. lists, sketches, etc.).

- Solutions will vary, students have freedom of creativity
- Look for diversity in solution types (e.g. lists, sketches, etc.)

Brainstorming solutions continued...

Choosing the Best Solution: Transfer your brainstormed solutions into a list here and narrow down your solutions. Use the following questions to help you in the narrowing process: How many requirements does it fulfill? Does it meet all the requirements? If not, can it be modified to meet all the requirements? If no solution meets all of the requirements, brainstorm more solutions.

- Solutions will vary, students have freedom of creativity
- Students should transfer their solutions onto this section and narrow their list

Once you have chosen a solution that best fits all of the requirements, explain why you chose that solution and how it meets all of your requirements.

- Solutions will vary depending on their response
- Students should explain how their solution fits each requirement given
    - How it would withstand against earthquakes
    - Structure in correlation with length/span

Name: _____ANSWER KEY_____ Date: _____

Exit Ticket: Engineering Design Process - Imagine

1. What are the steps within the *Imagine* portion of the engineering design process? List them.

   Brainstorm possible solutions
   Choose the best solution

2. What is the main focus of a brainstorming session?
   a. Quantity of solutions rather than quality
   b. Quality of solutions rather than quantity

3. What should you do if none of your solutions meet the requirements?
   a. Choose the solution that meets most of the requirements.
   b. Quit the project.
   c. Modify a solution until it meets all of the requirements or brainstorm more solutions

4. Which statement is **NOT** a part of the brainstorming guidelines?
   a. Stay focused on the topic
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   d. Only record the solutions that make sense

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: Imagine 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] What is Food Engineering. (n.d.). Retrieved from http://whatisengineering.com/topic/what-is-food-engineering/

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[3] 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.

[4] 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.

[5] 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.

[6] 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.

[7] Design Step 3: Brainstorm Possible Solutions - Activity. (n.d.). Retrieved from https://www.teachengineering.org/activities/view/cub_creative_activity3

This website was used for adaptation purposes within the Engineering Design Process: Imagine lesson plan as a part of the Engineering Design Principles module. This reference aided in the completion of the *Brainstorming Guidelines* handout through excerption and adaptation.

[8] Science Buddies. (2017). The Engineering Design Process: Brainstorm Multiple Solutions. Retrieved from https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/alternative-solutions

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.