SeaGlide_TEAM	Test and Improve	Lesson # 7 (60 minutes)

Description:
Students will focus on the *Test and Improve* portion of the engineering design process which includes testing prototypes and analyzing results. They will continue their roles as Civil Engineers as well as continue to work on their Bridge Design projects. This is the final lesson of the six lesson unit project. Students will test their finished prototypes as a class and record their testing process. After completion, students will revise their design based on the testing results.

Students will be able to:

- Test a prototype
- Use analytical evidence to improve their bridge design
- Use evidence to support decisions
- Define an abstract
- Explain the purpose of an abstract

Students will understand:
The *Test and Improve* portion of the engineering design process involves the testing, analyzation, and revision of a prototype. This part of the engineering design process is important because engineers can make sure the product works the way it was intended, can test how the solution works, and can receive feedback before producing the final product. Students will test their prototypes and revisie their designs based on the results yielded in the testing process.

Key Definitions & Concepts: [1]

- **Abstract**: a summary or concentration of essentials of a research article, thesis, or any analysis of a particular subject.
- **Feedback**: the transmission of evaluation or corrective information about an action, event, or process to the original or controlling source.
- **Scientific Report**: document that describes the process and results of technical or scientific research [2].
- **Scientific Writing**: technical form of writing that is designed to communicate scientific information to other scientists [3].

Standards: [Copied from: 4]
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:

- The Engineering Design Process
- Logical Thinking
- Organizational techniques
- Making connections

Science Practices: [Copied from: 5]	**Core Ideas: [Copied from: 6]**	**Cross Cutting Concepts: [Copied from: 7]**
• Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions • Obtaining, Evaluating, and Communicating Information	• Defining and Delimiting Engineering Problems • Developing Possible Solutions • Optimizing the Design Solution	• Cause and Effect • Structure and Function • Stability and Change • Patterns • Influence of Science, Engineering, and Technology on Society and the Natural World

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: Create 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 *Create* step of the engineering design process. The goal is to have students show that they have a full understanding of this portion of the engineering design process. This section should take 5 minutes to complete.

Explore:

Part I: Introduction: [8]

The instructor will hand out the *Prototyping and Testing Video* half sheet. Students will watch a short video (Video Link) that talks about how prototypes and how testing prototypes are important in the engineering design process. The purpose of the half sheet to have students understand the different reasons for why it is important to test prototypes and to determine effective ways to test them. The goal is to have students know what to look for when testing their prototypes with the main goal of breaking them. This section should take about 5 minutes to complete.

Part II: *Benchmark Lesson*: Testing Prototypes [9], [10], [11], [12]
Students will get into their Bridge Design project groups, the instructor will distribute the *Engineering Design Process: Testing and Evaluating* activity worksheet as well as their engineering design binder. The instructor will be incharge of setting up the prototype testing setup following the testing procedure listing on page 2 of the *Engineering Design Process: Testing and Evaluating activity worksheet*. Here is a video that demonstrates what the instructor should look for during testing. Students will then take turns testing their prototypes and recording the process on their worksheets. The prototypes should break during the testing process. If students would like to keep something to remember their designs, it is recommended that they take pictures of their prototypes. The amount of time it takes for this section to be completed depends on the number of groups. However, once a group is finished testing their prototypes, they can move onto the evaluation questions. Make sure to leave at least 30 minutes for students to complete the investigation lesson and exit ticket. Aim to complete this section in 20 minutes maximum.

Part III: *Investigation Lesson*: Revising Bridge Designs
Once students are finished testing their prototypes, students will remain in their groups and work through the evaluation questions. Students will assess their the results of their testing and answer the questions assessing whether or not their design met the requirements. Students will work together and theorize reasons for why their bridge may or may not have worked. Students will then compare their designs to general descriptions of how the different bridge types may react in the event of an earthquake. Using those descriptions, students will make a final prediction of whether their bridge would withstand earthquake activity. Students will finally discuss ways to improve their design to be more safe and efficient. The purpose of this section is to have students find new ways to improve their design and see that the engineering design process is a continuous iterative process. This section should take about 15 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 section of the lesson. 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. Testing and improving 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: [13], [14]

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 observing how students work through the test and revising 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: Making the Connection to Scientific Writing* is a 15 minute, individual activity which has the student briefly outline what an abstract would look like in the event that they were to prepare a final scientific report on their bridge design process. The students should be given 10 minutes to complete the exit ticket so that the remaining 5 minutes can be utilized for the teacher's discussion. The instructor will then hold a class discussion talking about the purpose of an abstract. Reference the *Exit Ticket Discussion* for guidelines. The purpose of the exit ticket is to see if students have an understanding of scientific writing, a scientific report, and an abstract. The instructor should not focus on the correctness of the students' response, but focus on how much the student understands about each topic.

Enrich:

The lesson could be differentiated by having university students create a mobile application (app) of their choice. Students will create a prototype of their mobile application and have other students or anyone not associated with the product test the applications and give feedback. This would allow for students be made aware of any flaws and make sure the application works the way it was intended. This type of prototype testing can been seen in college-level courses and can be carried into real-world application development careers.

All associated documents are attached below
Reference *Annotated Bibliography* on the very last page of this packet

Name: ____ Date: ______________

Engineering Design Process: *Create* Review

1. Why is prototyping an essential part of the Engineering Design Process?

2. Which of the following is **NOT** a benefit of prototyping?
   a. Made with cheaper and easier to use materials
   b. Allows for feedback
   c. Allows to test how the solution works
   d. To conduct more background research

3. Why is it important to take notes of your building process of your prototype?

Name: ____ Date: ______________

Engineering Design Process: *Create* Review

1. Why is prototyping an essential part of the Engineering Design Process?

2. Which of the following is NOT a benefit of prototyping?
   a. Made with cheaper and easier to use materials
   b. Allows for feedback
   c. Allows to test how the solution works
   d. Made with the material intended to build the final solution

3. Why is it important to take notes of your building process of your prototype?

Name: ____ Date: _______________

Prototyping and Testing Video Worksheet [8]

1. Why is it better to test your design and experience failure in the early stages of your design process?

2. What are the different reasons to test a prototype mentioned in the video?

3. What is one effective way to test a prototype?
    a. Test them yourself
    b. Have people not associated with your product test them
    c. Have your coworkers test them

Name ____ Date: _______________

Prototyping and Testing Video Worksheet [8]

1. Why is it better to test your design and experience failure in the early stages of your design process?

2. What are the different reasons to test a prototype mentioned in the video?

3. What is one effective way to test a prototype?
    a. Test them yourself
    b. Have people not associated with your product test them
    c. Have your coworkers test them

Name: ____ Date: ____________
Engineering Partner Name: ____

Engineering Design Process: Testing and Evaluating [9]

Introduction: Prototype testing is an important part of the engineering design process. Engineers test prototypes to confirm whether the product will work as it is intended to, or if it requires refinement. They test how the solution works and receive feedback, allowing for further development of the structure, function, and appearance of their solution. Testing a bridge prototype also helps identify potential design faults and allows for improvement, it can also be tested against any relevant regulations and legislation. This allows for validation before final development and construction.

Engineering Design Process:

Ask
Imagine
Plan
Create
Test → Test the prototype
Evaluating the results
Improve and redesign

Directions: Today, you will continue your role as a Civil Engineer and focus on the *Test and Improve* portion of the engineering design process. In the last lesson, your team has constructed a bridge prototype based on your extensive research, planning, and development. Now it is time to test your prototype for safety and function. Since your prototype is a scaled down version of your bridge, you will primarily be testing for weight capacity and structure. You will test your design to see if can withstand 25 lbs., however, you will also test to see if your design can hold the max amount of sand at around 60 lbs.

Things you will be testing for today:

- **Length**: does your prototype have a span of 30 in.

- **Weight Capacity**: does your prototype pass the 25 lb. weight limit? What is the maximum amount of weight it can hold?

- **Structure and Design**: is the structure of your bridge strong enough to withhold the effects of an earthquake? Would your bridge experience minor damages or would it collapse?

➢ Use the space below to record your testing process, make sure to note the weight of the bucket(s) after your bridge broke. If your bridge was able to hold all of the sand without breaking, record the weight of buckets.

Bridge Design Testing Procedure [9]

Materials:

- two 3 gallon buckets
- one 60 lb. bag of sand
- strong string
- block / object
- scale
- cup/small container
- two tables

Procedure:

1. Cut 4 to 6 pieces of string, that are about 100 cm long

2. Secure one end of the string(s) to the handle of each bucket

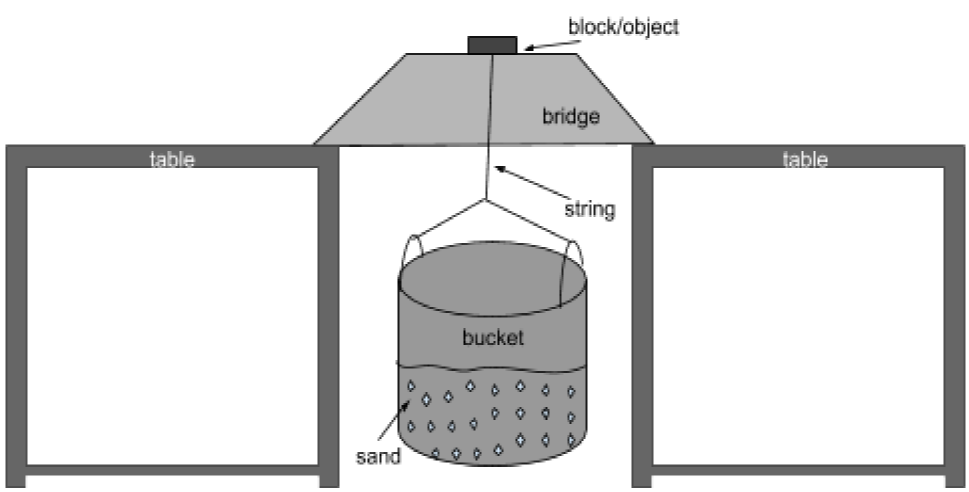
3. Set the tables about 20 in. apart, place the bridge in the middle of the free space that is between the two tables (about 5 in. of each end of the bridge should be supported on each end of the tables)

4. Thread the other end of the string through the bridge (from bottom to top) and secure it to the block/object (make sure to leave less than 70cm of the string free, so that the bucket is elevated off the ground)

5. Using the small container, pour sand into the bucket in slow increments until the bridge breaks, or all the sand has been deposited into the buckets

6. After the testing is finished, measure the final weight of the bucket, string(s), block, and sand

***Included below is an schematic of the testing procedure set-up for reference*



Evaluation Questions

1. Did your bridge meet the 25 lbs. requirement? If not, explain possible reasons why. Use evidence to support your response.

2. What was the maximum amount of weight your bridge was able to withstand before it broke? What does this tell you about the structure of your design? If your bridge did not break, explain why you believe your design withstood a large amount of weight. Use evidence to support your responses.

How Would this Bridge React in the Event of an Earthquake? [10-13]

- **Suspension Bridge**: performs better than most other bridges in the event of an earthquake with the addition of a truss system for extra support. When dealing with long distances and potential natural disasters, suspension bridge are include a great combination of structures that help support it in unstable environments. If materials like concrete were used, soil liquefaction could become an issue.

- **Cable stayed Bridge**: performs better than other bridges but contain seismic weak points that become dangerous in the event of an earthquake. Could pass with minor damages but if materials like concrete were used, soil liquefaction could become an issue. Extremely similar to a suspension bridge and can be a budget friendly option.

- **Cantilever Bridge**: since it is a mixture between a beam bridge and a truss, it can support heavy traffic. It is likely to withstand an earthquake but may require seismic reinforcements afterwards.

- **Arch Bridge**: since the span is required to be 1500 ft., a beam bridge would collapse because it is not recommended to span more than 800 ft.

- **Beam Bridge**: since the span is required to be 1500 ft., a beam bridge would collapse because it is not recommended to span more than 250 ft. Additional supports such as piers and trestles could be used to support longer distances.

- **Drawbridge**: due to the complexity in design and function, a drawbridge could contain several different parts that become dangerous in the event of an earthquake such as counter balances. Since there will be no water traffic, a drawbridge is not necessary in this scenario.

3. Above are general descriptions of how different bridge types may react in the event of an earthquake, compare your bridge design to those descriptions. Would your bridge withstand in the event of an earthquake? If not, explain why and use evidence to support your response.

4. Although you will not implement your improvements, and you will not continue to work on your bridge design, answer the following question:
   Depending on the results of testing your design, explain how you would improve your bridge design. If your bridge did not pass the required weight and/or did not match the bridge types listed above, explain how you would revise your design so that it would meet the requirements.

Name: ____ Date: ______________

Exit Ticket: Making the Connection to Scientific Writing [14]

Introduction: Scientific writing is essential in science; it allows scientists to document and to communicate ideas, research, and findings. There are several forms in which scientific writing can be published. However, a common form is a final scientific report. This report describes the process and results of technical or scientific research. These reports can often be lengthy, and therefore makes it difficult when scientists are looking for a certain report. Abstracts are used to allow people to learn the overview of what a final scientific report is about without having to read the entire report. They highlight the key points from major sections of the scientific report. Writing an abstract is essential part of scientific writing because it captures the reader's attention and it allows them decide whether or not it is worth their time to continue reading. Final scientific reports can also be used in engineering to describe the process and the results of an invention or innovative idea.

Similarities between the Engineering Design Process and Scientific Writing: In the past six weeks, you have been learning about the Engineering Design Process. The iterative process includes specific steps that are followed in each step. Similarly, an abstract contains different sections that discuss specific research, processes, and findings that have occurred in an experiment / innovative process. Below you can see a general overview of both the engineering design process and an abstract.

Engineering Design Process Overview	Scientific Writing: Abstract Overview
Ask	Introduction
Imagine	Problem Statement
Plan	Procedures
Create	Results
Test and Improve	Conclusions

Directions: Below, write a brief outline of what your abstract would look like if you were to write a final scientific report about your design process and about the results pertaining to your bridge design project. Use the table above and what you have learned about the engineering design process to show how you would organize an abstract and write what you think should be included in each section. Make sure to list detailed bullet points or short sentences, keep in mind that an abstract is usually no longer than 1000 words. We will then discuss the specific details that go into each section of an abstract as a class.

1. **Introduction:**

2. **Problem Statement:**

3. **Procedure:**

4. **Results:**

5. **Conclusion**

Name: _________ANSWER KEY_________________________________ Date: ________________

Engineering Design Process: *Create* Review

1. Why is prototyping and essential part of the Engineering Design Process?

   Prototyping is essential to the engineering design process because it allows engineers to save time and money by making sure that the product works the way it was intended, by testing how the solution works, and by receiving feedback before producing the final product.

2. Which of the following is NOT a benefit of prototyping?
   a. Made with cheaper and easier to use materials
   b. Allows for feedback
   c. Allows to test how the solution works
   d. Made with the material intended to build the final solution

3. Why is it important to take notes of your building process of your prototype?

   It is important to record the building process of the prototype to have something to refer back to in case something went wrong with the prototype. Engineers can refer back to their notes to make sure their construction followed their design.

Name: _________ANSWER KEY________________________________ Date: ________________

Prototyping and Testing Video Worksheet [8]

1. Why is it better to test your design and experience failure in the early stages of your design process?

   It is better to test your product when it is cheap and fast in order to migrate risk.

2. What are the different reasons to test a prototype mentioned in the video?

   Test the design to failure
   Find any inherent flaws
   Make sure it's safe and works

3. What is one effective way to test a prototype?
   a. Test them yourself
   b. Have people not associated with your product test them
   c. Have your coworkers test them

Name: _________ANSWER KEY_________________________________ Date: _________________
Engineering Partner Name: ____

Bridge Design Testing Procedure [9-13]

Evaluation Questions

1. Did your bridge meet the 25 lbs. requirement? If not, explain possible reasons why. Use evidence to support your response.

   Student responses will vary; reasoning and evidence should include structure, design, and bridge type.

2. What was the maximum amount of weight your bridge was able to withstand before it broke? What does this tell you about the structure of your design? If your bridge did not break, explain why you believe your design withstood a large amount of weight. Use evidence to support your responses.

   Student responses will vary; reasoning and evidence should include structure, design, and bridge type.

3. Above are general descriptions of how different bridge types may react in the event of an earthquake, compare your bridge design to those descriptions. Would your bridge withstand in the event of an earthquake? If not, explain why and in what ways using evidence to support your response.

   Student responses will vary.

   The bridge types that should withstand an earthquake are a suspension bridge, a cable stayed bridge, and a cantilever bridge. However, the durability of these bridge types depend on the materials the students have decided to use. A general good rule of thumb is if the students have chosen any of the bridge types previously listed but used a material such a concrete, the bridge will not survive an earthquake. On the other hand, if the material used is steel, the bridge has a better chance of surviving an earthquake.

4. Although you will not implement your improvements and you will not continue to work on your bridge design, answer the following question:
   Depending on the results of testing your design, explain how you would improve your bridge design. If your bridge did not pass the required weight and/or did not match the bridge types listed above, explain how you would revise your design so that it would meet the requirements.

   Student response will vary

   If the bridge did not pass, most commonly students may change the material or overall bridge type. If the bridge did pass, students may add interesting features they may have learned about. An example of this could be tuned mass dampers used in the Akashi Kaikyo Bridge.

Name: _________ANSWER KEY___________________________________ Date: _________________

Exit Ticket: Making the Connection to Scientific Writing [14]

Introduction: Scientific writing is essential in science; it allows scientists to document and to communicate ideas, research, and findings. There are several forms in which scientific writing can be published. However, a common form is a final scientific report. This report describes the process and results of technical or scientific research. These reports can often be lengthy, and therefore makes it difficult when scientists are looking for a certain report. Abstracts are used to allow people to learn the overview of what a final scientific report is about without having to read the entire report. They highlight the key points from major sections of the scientific report. The abstract is an essential part of scientific writing because it captures the reader's attention and it allows them decide whether or not it is worth their time to continue reading. Final scientific reports can also be used in engineering to describe the process and the results of an invention or innovative idea.

Similarities between the Engineering Design Process and Scientific Writing: In the past six weeks, you have been learning about the Engineering Design Process. The iterative process includes specific steps that are followed in each step. Similarly, an abstract contains different sections that discuss specific research, processes, and findings that have occurred in an experiment / innovative process. Below, you can see a general overview of both the engineering design process and an abstract.

Engineering Design Process Overview	**Scientific Writing: Abstract Overview**
Ask	Introduction
Imagine	Problem Statement
Plan	Procedures
Create	Results
Test and Improve	Conclusions

Directions: Below, write a <u>brief</u> outline of what your abstract would look like if you were to write a final scientific report about your design process and the results pertaining to your bridge design project. Use the table above and what you have learned about the engineering design process to show how you would organize an abstract and write what you think should be included in each section. Make sure to list detailed bullet points or short sentences, keep in mind that an abstract is usually no longer than 1000 words. We will then discuss the specific details that go into each section of an abstract as a class.

1. **Introduction:**

   <u>Talk about the purpose of the design project and why it was important to the public: students can talk about safety and convenience in this section.</u>

2. **Problem Statement:**

   Restate the problem statement and the constraints that led the bridge design project.

3. **Procedure:**

   Bulk of the abstract;
   Students should talk about their approach for the design process and their thought process leading up the construction of the prototype. However, students should not go into any specifics in this section.

4. **Results:**

   Talk about the results yielded in the prototype testing.

5. **Conclusion:**

   Main point: did the prototype meet the design criteria? Did the student have to go back and revise their design to met the criteria, or did students focus on improving the design and adding unique features?

Exit Ticket Discussion [14] [15]

Ask students to explain what a scientific report and an abstract are and why are they important in STEM.

- Briefly explain the importance of science writing and why abstracts are used
- **Scientific Report**: writing about science for non-science audiences; document that describes the process, progress, and results of technical or scientific research
    - Importance:
        - Used to document and communicate ideas and findings
        - Focus on transmitting information with a clear purpose to a specific audience
        - Commonly used in industry
- **Parts of a Scientific report**:
    - Title Page
    - Table of Contents
    - Abstract
    - Introduction
    - Experimental Materials and Methods
    - Results
    - Discussion
    - Conclusion
    - References
- **Abstract**: abbreviated version of the final report
    - Consists of a word limit: 150 - 1000 words
    - Provides an overview of the report (i.e. full summary)
    - Highlight key points of major sections of the scientific report
    - Captures the reader's attention and interest
    - **Parts of an Abstract:**
        - Introduction
        - Problem statement
        - Procedures
        - Results
        - Conclusion
    - Sections in depth:
        - Introduction:
            - Provides background information to the motivation specific question addressed
            - Describes the purpose of the study, experiment, invention, etc.
            - Motivate the reader to finish the abstract and read the entire paper
        - Problem Statement:
            - Identify the problem solved / hypothesis investigated
        - Procedures:
            - What was your approach for investigating the problem
            - Don't go into detail about materials unless they were critical to your success
            - Describe the most important variables if there is room
        - Results:
            - What answer was obtained?
                - Be specific and use numbers to describe the results
                - Do not use vague terms like "most" or "some"
        - Conclusion:
            - State what your work contributes to the areas you worked in
            - Did you meet your objectives
            - Engineering: did you meet your design criteria

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: Test and Improve 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] Www-Liby@waikato.ac.nz. (n.d.). Writing a Scientific Report. Retrieved from https://www.waikato.ac.nz/library/study/guides/write-scientific-reports

This website was used for adaptation within the Engineering Design Process: Test and Improve 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 section. The key concepts and definitions were adapted based on the grade and activities at-hand.

[3] Write Like a Scientist. (n.d.). Retrieved from http://sites.middlebury.edu/middsciwriting/overview/

This website was used for adaptation within the Engineering Design Process: Test and Improve 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 section. The key concepts and definitions were adapted based on the grade and activities at-hand.

[4] 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.

[5] 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.

[6] 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.

[7] 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.

[8] UNSW. (2017). Innovation 101 E4: Prototyping & Testing - Physical Products. Retrieved from https://www.youtube.com/watch?v=2PzT0aAi9Lw

This video was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. Questions were developed based on this video for students to answer within the exploration portion of the lesson.

[9] Management, S. R. (2017). Physics Students' Bridge Designs Get Tested. Retrieved from https://www.youtube.com/watch?v=R7ckmaB50Dg

This video was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided as a tool for the instructor to have a visual example of the process for testing a bridge prototype. This reference was neither adapted nor excerpted.

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

This website was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of the materials and procedure portion of the *Bridge Design Testing Procedure* worksheet.

[11] Explore More with Facts for Now. (n.d.). Retrieved from http://factsfornow.scholastic.com/article?product_id=nbk&type=0ta&uid=11410428&id=a2003640-h

This website was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of descriptions for the probability of how different bridge types would react in the event of an earthquake through adaptation.

[12] Bridge Basics. (2001). Retrieved from https://www.pbs.org/wgbh/buildingbig/bridge/basics.html

This website was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of descriptions for the probability of how different bridge types would react in the event of an earthquake through adaptation.

[13] Wonders of the World Databank. (n.d.). Retrieved from https://www.pbs.org/wgbh/buildingbig/wonder/structure/akashi_kaikyo.html

This website was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of descriptions for the probability of how different bridge types would react in the event of an earthquake through adaptation.

[14] Science Buddies. (2017). How to Write a Science Fair Project Abstract. Retrieved from https://www.sciencebuddies.org/science-fair-projects/science-fair/how-to-write-a-science-fair-project-abstract

This website was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of the *Scientific Writing: Abstract Overview* table as well as the *Exit Ticket Discussion* through adaptation and excerption.

[15] Www-Liby@waikato.ac.nz. (n.d.). Writing a Scientific Report. Retrieved from https://www.waikato.ac.nz/library/study/guides/write-scientific-reports

This website was used for adaptation within the Engineering Design Process: Test and Improve lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of the *Exit Ticket Discussion* through adaptation and excerption.