

Escape the Lava

The Tech Challenge 2018 Lesson 1: English Language Arts

Developed by The Tech Academies of Innovation

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I. Lesson Overview

Lesson Description:

Students will design devices to help “Justin Case” escape lava by using items in their backpacks to get Justin from one tree to another. Students will use the knowledge they gain from this engineering design challenge to practice the skills, vocabulary, and presentation techniques of engineers.

Grade Level: 4-8

Education Outcomes:

Students will:

- Design and build devices to solve an engineering design challenge.
- Assess their designs for failure points and areas for iterative improvements.
- Analyze presentations to identify key components of good presentations.
- Create presentations to explain the strengths and weaknesses of their designs in meeting criteria and constraints of a design challenge.
- Demonstrate their abilities to integrate the lexicon of engineering in their presentations.
- Create engineering diagrams.

Education Standards

Met: (Note: bolded parts of the standards are fully met by this lesson)

NGSS Disciplinary Core Ideas (DCI):

[4-5th] CCSS.ELA-LITERACY.CCRA.SL.4 **Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.**

[6-8th] CCSS.ELA-LITERACY.SL.6.4 **Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.**

NGSS Science and Engineering Practices (SEP):

[4-5th] **Obtaining, evaluating, and communicating information: Communicate scientific and/or technological information orally** and/or in written formats, including various forms of media and may include tables, **diagrams**, and charts.

[6-8th] **Obtaining, evaluating, and communicating information: Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.**

NGSS Crosscutting Concepts (CCC):

[4-5th] Systems and System Models: **A system can be described in terms of its components** and their interactions.

[6-8th] Systems and System Models: **Systems may interact with other systems;** they may have sub-systems and be a part of larger complex systems.

[6-8th] Stability and Change: **Small changes in one part of a system might cause large changes in another part.**

II. Advanced Prep & Set-up for Lesson

Materials (per approximately 30 students)

Note: Many of these materials are suggestions based on what students have found useful. This is not a limiting list – feel free to add other materials that you think may be useful to building the simple machines in this lesson. Think creatively and use materials you have on hand!

- Have a mix of building materials available for building, such as the following:
 - 50 bendy straws
 - 50 assorted colored chenille stems (pipe cleaners)

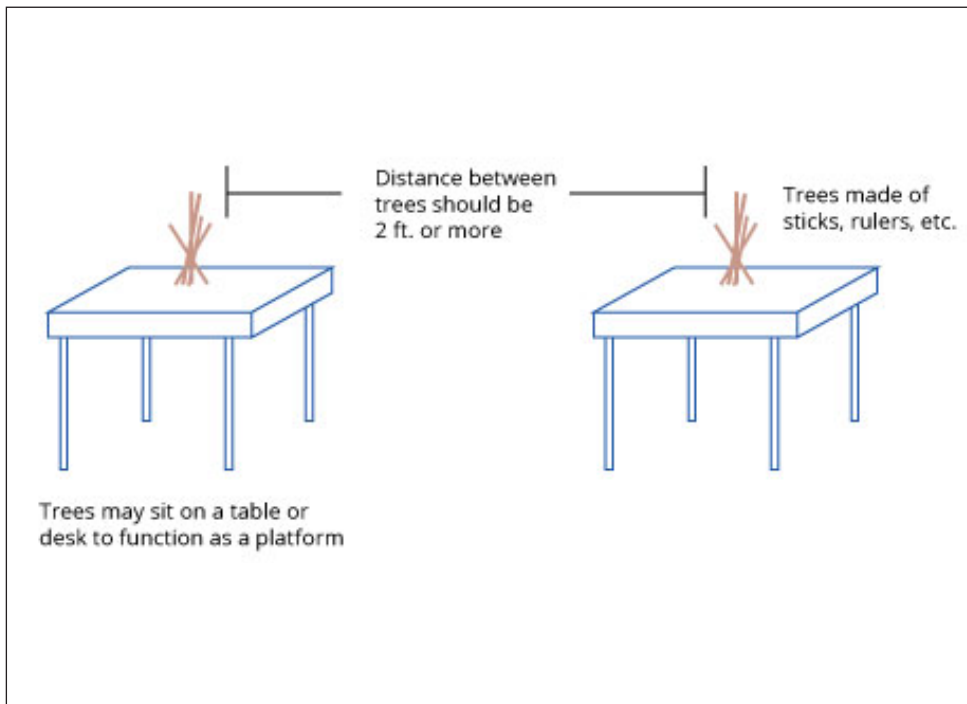




- 40 large butterfly clips
 - 50 craft sticks
 - 50 jumbo craft sticks 6"x 3/4"
 - 80 rubber bands - various sizes
 - 40 clothespins - various sizes
 - String, cut into foot-long pieces
 - 30 springs - various sizes
 - 30 plastic spoons
 - 50 binder clips - various sizes
 - Other materials as you see fit
- Lava can be made up of red fabric, crumpled up red craft paper, etc.
 - Trees for the rig can be made out of sticks or by placing 2 desks 2 feet apart from each other.

Set-Up

1. Have the "trees" set up in a central location so that groups can do test trials as they build. Place the trees two feet apart.



Example of a "tree" built with recycled materials.

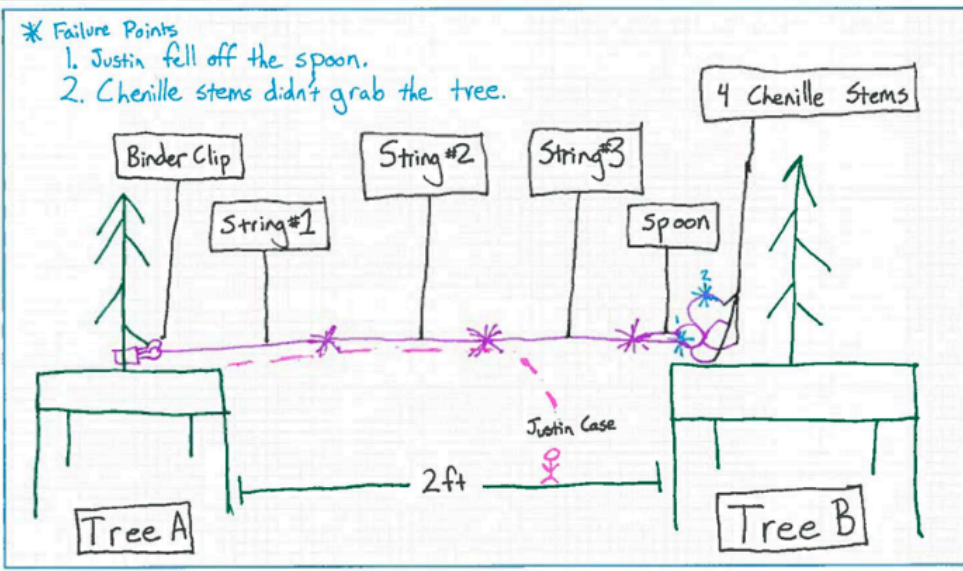


2. Data Collection and Observations:

- Ensure that all students have a copy of the Data Collection handout to record their prototype designs and iterations based on the observations they make. (Appendix E, Data Collection: How We Escaped the Lava [4-8th grade])
- A sample of a filled-in Data Collection Sheet is in Appendix E. (Appendix E, Sample Data Collection Worksheet)

Data Collection: How We Escaped the Lava

Each sketch should include the following:
 A. Diagram your device to show how it is used to transport Justin Case get from one tree to the other.
 B. Label all of the components.
 C. Label any failure points.

Date: September 4, 2017	Prototype #: 1	Name: Justin Case
<div style="border: 1px solid black; padding: 5px;"> <p>* Failure Points 1. Justin fell off the spoon. 2. Chenille stems didn't grab the tree.</p>  </div>		
Criteria and constraints this solution DOES meet: 1. I drew and labelled our solution. 2. We designed a solution in 15 minutes. 3. We did not reach beyond Tree A.	Criteria and constraints this solution DOES NOT meet: 1. Justin Case landed in the lava. 2. We used 9 materials instead of 5.	
To improve on our prototype, some improvements we can make are: <u>We will improve our prototype by creating a solution that will hold on to Tree B. Next time we will use 3-5 materials.</u>		

III. Escape the Lava Lesson Guide

Guiding Question: how does an engineer effectively share their design ideas with others?

A. Introduction (10 Minutes)

1. Lead a discussion to introduce the concept of engineering.
 - *Whenever you work to create a solution to a problem, you are an engineer!*
 - Explain to students what engineering is and how it connects to science.
 - *Engineers use evidence gathered by themselves, other engineers, and scientists to solve problems.*
 - Identify times students have worked as engineers, as they solve problems in their own lives and in the classroom.
 - *Tell me about a time when you had to solve a problem or fix something that was broken? (Possible answers could include: fixing a bike or making a present.)*
 - Explain how scientists and engineers are different.
 - *Science is about finding knowledge about how and why the world works whereas engineering is about using that knowledge to solve problems. Science uses a method to experiment and observe to verify knowledge. Engineering uses a process to build, test, and create. Both fields use math, modeling, creativity, and reading/writing.*
2. Introduce background information for the Design Challenge scenario by showing a video of a volcano erupting. Possible videos include:
 - BBC report on a volcano erupting in Chile near the town of Pucon.
(www.bbc.com/news/av/world-latin-america-31705977/villarrica-volcano-eruption-puts-chile-on-alert)
 - Video with music that demonstrates the destruction of flowing lava from a volcano.
(www.youtube.com/watch?v=qA8D8e34LZc)
 - Ask students questions to start imagining the situation. Encourage creative ideas and out-of-the box thinking!
 - *If you were on a small island where a volcano started to erupt, what would you do? How would you find safety?*
3. Introduce the engineering design challenge big picture.
 - *You are part of a team of volcanologists and geologists studying a volcano when it suddenly erupts. In the surprise and confusion you have been separated from your team and climb a tree to safety. Now you are stranded in a tree with lava coming in from all sides! A group of trees nearby is still lava-free. Though you are unable to jump that far, you feel confident that you can create a solution using only what is in your backpack to transport yourself safely to the other tree. As an engineer who solves real-world problems, how will you achieve success?*

To keep yourself calm as you work to solve this problem, you think about the panel you and your team will be on next week for the Expedition Channel special on volcanos. You will have to remember and document everything you do today, so you can recount the story to the audience next week.

B. Escape the Lava Engineering Design Challenge (30-50 minutes)

Educator Note: for more information on teaching the Engineering Design Process, see “Engineering Design Process” in Appendix C and links in Appendix D.

1. Introduce concepts of criteria and constraints
 - *Has there ever been a time you managed to do something that at first you didn't think you could possibly do?* (Possible situations include: go to Disneyland, play on a sport's team, go to a movie, have a playdate, get a new toy, make a project that required special materials or adult supervision, etc.)
 - Lead a discussion about the obstacles to achieving the goal.
 - *What were the challenges you needed to overcome? Were there any rules you needed to follow to accomplish your goal?* (Possible answers include: money restrictions, limited time, transportation access, parental permission, age restrictions, and height restrictions.)
 - *Did you achieve your goal? How did you do it?* (Students might talk about: convincing or negotiating with a family member, tradeoffs, realizing the goal wasn't what they really wanted, pooling resources like time or money with other people, etc.)
 - *In the situation(s) you have described you did the work of engineers. When you identified a goal, figured out the rules and challenges, and then found a solution you used the same skills that engineers use to solve problems and design solutions.*
 - *Since we are engineers as we design solutions to this challenge, we are going to use engineering rules and language. All engineers use the words **criteria** and **constraints** to describe the goals and rules for achieving a solution to a problem.*
2. Introduce criteria.
 - *Criteria are the goals for a project. What do you want the solution to do? How well will it work? Are there any rules about how it needs to look or the size it needs to be? Does the solution need to work only once or every day for 10 years?*
 - Ask students to identify the criteria from their situations discussed in B1.
 - Ask students to identify possible criteria for building a new playground at their school. (Possible answers could include: it has to look nice, it has to work every day for many years with kids hanging and climbing on it, it has to be safe, it has to be able to hold the weight of ten 5th graders at once, etc.)
3. Introduce constraints
 - *Constraints are the rules or limits for a project based on real-world limitations that exist around the challenge. Where will we be making this project? How much time do we have? What are the laws, rules, and procedures we need to follow? Are there any specific materials we need to use? What tools do we have to achieve our goals? Constraints always include budget and schedule. Budget is the cost (in our case, the materials) and schedule is how much time you have to come up with a final solution.*
 - Ask students to identify the constraints from their situations discussed in B1.
 - Ask students to identify the constraints for building a new playground at their school.(Possible answers could include: the playground must be located at our school so will be constrained by the size/shape of a given area, must meet safety regulations to protect students, must be able to be built for less than \$5,000, must be designed and installed between May and August so it's in place before school starts.)



4. Introduce the engineering design challenge

- *Now that we all understand the important components of an engineering problem, it's time to be engineers and take on our first challenge!*

Design Problem:

- *You are stuck in a tree and surrounded by lava. Use the objects in your backpack to make a device to get you from the tree you are in to the next closest tree.*

Criteria (Design Requirements/Desired Features):

- Transport the "Justin Case" figure from Tree A to Tree B without touching the lava.
- All team members their solutions by drawing them and labelling the pieces on the data collection handout.

Constraints (Design Limitations):

- Budget: 2-5 materials from Justin Case's 'backpack.' Students may pick these materials from the table.
- Schedule: Teams have 15 minutes to create and test their devices before the tree falls into the lava.
- When testing their solutions, students' bodies may not extend beyond Tree A; it is too far for Justin Case to reach or jump to Tree B.

Testing:

- Test the designs at the rig during build time to test different prototypes and find failure points in the designs.

5. Imagine Possible Solutions.

- Review the classroom agreements, especially as they relate to small group work and collaborative work
- Lead a short group discussion on ways to brainstorm. (See Appendix C, "Brainstorming")
- Give groups time to brainstorm on how they want to solve this problem. While students are brainstorming, ask them facilitative questions. Possible questions include:
 - *Which materials are you considering for your device?*
 - *How do you think the materials will work together?*
 - *What have you see in the real world, television, movies, or books that may help you solve this problem?*
- Give groups time to look at the materials table together, as part of their brainstorming process.

6. Create prototypes

- Give students 15 minutes to collect materials and start building. Students can test parts of their solution or complete devices on the rig during this time.
- Walk around and observe the team. Look for patterns in devices, frustration points, and similarities in designs to discuss with the class during the share out.
- While students are working ask teams facilitative questions to help them guide their thinking and their process.

Possible questions include:

- *What is working well in your design?* (Students may need help identifying these points in their designs. Help them think about specific parts where the design is doing what they are intending it do.)
- *What did you do to help with this solution?*
- *How does this part of your device work?*



7. Sharing solutions – group testing and reflection

- Have the students return to their desks at the end of the 15-minute build time.
- Introduce Prototypes
 - *Engineers, you have designed your first **prototype**. What do you think a **prototype** is?* (Possible answers include: A prototype is a possible solution, rough draft, first try, etc.)
- Explain to students the process of testing their solutions as a class.
 - [4-5th] *Next we are going to all come up to the rig and watch each team test their device. Each team will get up to three chances to demonstrate their prototype. Then the team is going to tell us about their design and what inspired them, including specifically which **components**, or materials, they used in their prototype. When the team is done sharing we will clap and then the next team will present.*
 - [6-8th] *Next we are going to all come up to the rig and watch each team test their device. Each team will get up to three chances to demonstrate their prototype. Then the team is going to tell us about their design and what inspired them, including specifically which **components**, or materials, they used in their prototype. Explain how each of the components work together as a solution and why they are combined in that specific order for the solution. When the team is done sharing we will clap and then the next team will present.*
- Have every team test their device at the rig and share out about their prototype.
- Ensure that students are comfortable with failure being part of the process of engineering. As students are testing their devices, it is important to celebrate the failures that students may experience during the design process. Instead of “Oh no, that doesn’t work!” try
 - *Now you know what happens when you try that! You have more information!*
 - *What did you learn from that?*
 - *What will you try next to improve your design?*
- Failure is an important part of the design process and should be celebrated as a positive way to learn. It is important to remind students that there is no single “right” answer in engineering; one problem can have many solutions.

8. Document prototypes

- Ask students to return to their desks.
- Introduce the concept of **failure points**.
 - *A failure point is the spot where your device stops working – a design element that can cause an unsuccessful result. Sometimes there is one failure point and sometimes there are many. As we work toward iterating our designs it is important to look for any points that specifically didn’t work so we can make our next designs work better.*
- Give each student a Data Collection Worksheet (See Appendix E, Data Collection: How We Escaped the Lava).
 - [4-5th] *Each student will be responsible for drawing a sketch of your team’s device, labeling the components, identifying the failure points, and adding suggestions on ways the design could be improved. These drawings and notes are important as they will help you create your final presentation.*
 - [6-8th] *Each student will be responsible for drawing a sketch of your team’s device, labeling the components, identifying the failure points, and adding suggestions on ways the design could be improved. With your suggestions for the next iteration, consider how you combined the components. Are there ways to recombine the components to make the solution achieve your team’s goals?*



Can one change in the system make a different component perform in a new way? These drawings and notes are important as they will help you create your final presentation.

- A Sample Data Collection Worksheet is provided in Appendix E to use as a model with students. Specifically address what is expected for the drawings and labels in their diagrams. (See also Appendix C, "Journaling.")

C. Content Learning (30-50 min)

1. Introduce the value of presenting skills as an engineer.

- *Engineering firms present proposals to clients to try and secure new business or to explain design concepts to clients.*
- Lead a discussion with students about what they think are good presentation skills. If presentation skills haven't been covered in class before, consider showing a video of a strong presentation. This could be a Ted Talk (www.ted.com/playlists/171/the_most_popular_talks_of_all), or even a video by Kid President (www.kidpresident.com). Chart their responses somewhere so the class can refer to them often. This list should be a brainstorm and it may be incomplete. The list will be revisited later in this part of the lesson to add more ideas.
- You may want to refer back to the topics brought up in the introduction of criteria and constraints to help students identify persuasive speech techniques.

Possible questions to help guide students include:

- *What presentations have you seen?*
- *What presentations have you given?*
- *What do you think is important in a compelling presentation?*
- *What do you say or do to try and convince someone to see things from your perspective?*

2. Introduce the mini presentation challenge

Presentation Challenge

- *Develop a team presentation based on your observations of the first test, observing other teams, and reflecting on your team member's Data Collection Worksheets.*

Criteria

- *Discuss how your prototype addressed the criteria and constraints of the design challenge.*
- *Explain what your team would do differently in their next **iteration** of the design. Iteration is the next version of your prototype that makes it better in some way. It's like the newest version of a phone or a video game.*
- *Demonstrate your team's abilities to use the presentation skills from the class chart.*

Constraints

- Presentations should last 3-4 minutes. Educator Note: This is an estimated time to give a group of four students approximately one minute apiece. This time can change depending on the needs of the students and the sizes of the teams.
- Each team member must present a portion of the content in the presentation. Possible presentation division for a team of 4: introduce the team with team name, description of the prototype and thought process; how the prototype meets the criteria; how the prototype meets the constraints; plans for a future iteration.)

Role of Audience Members

Each member of the audience will:

- Analyze each presentation for how it meets the class list of presentation skills.
- Compose one post-it note to each team telling them one thing they did well in their presentation.
- Create follow-up questions to ask at the end of the presentations to help teams clarify their ideas. (See Appendix , “Scaffolding Strategies”)
- Record one area of growth for the team to work on in future iterations of the presentation, which you can disseminate to teams after presentations.

3. Plan and develop presentations

- Give teams 15 minutes to create and practice their presentations.
- Distribute post-it notes to each student for use during the presentation.

4. Have teams give presentations to the class.

- Have students give their post-it notes to you at the end of each presentation.
- Ask follow-up questions to help students clarify their points and practice impromptu speaking.
- Encourage students to ask questions of the teams.

5. Reflect on the presentations as a class.

- Give the positive post-it notes to each team to review.
- Ask each student to take a minute to think about what they saw in the presentations that was strong and other presentation skills they think we should add to the class list.
- Give teams 3 minutes to discuss their ideas with each other.
- Ask students as a class to review the list of presentation skills and see if there is anything they should add based on what was observed of the presentations. (See Appendix C, “Teaching Presentations”)
- Options to add to the list based on Common Core Standards are:
 - Elaborate on the ideas of others. (CCSS.ELA-LITERACY.SL.5.1.C)
 - Provide possible iterations based on discussions and observations. (CCSS.ELA-LITERACY.SL.5.1.D)
 - Information is presented in a logical/sequential order. (CCSS.ELA-LITERACY.SL.5.4, SL.6.4)
 - Teams talk about their design in terms of criteria and constraints. (CCSS.ELA-LITERACY.SL.5.4)
 - Teams use visual aids to enhance their points. (CCSS.ELA-LITERACY.SL.5.5)
 - Students use the words of scientists and engineers in their presentations. (CCSS.ELA-LITERACY.SL.5.6)
 - Students use transition words appropriately. (CCSS.ELA-LITERACY.SL.5.4a)
 - Students support main ideas with appropriate details. (CCSS.ELA-LITERACY.SL.6.4)
 - Students use eye contact and room scanning to engage the audience. (CCSS.ELA-LITERACY.SL.6.4)
 - Students use appropriate volume and pronunciation in their presentations. (CCSS.ELA-LITERACY.SL.6.4)
- Optional areas for advanced growth in presentation skills
 - Students decrease their use of filler words like ‘um.’
 - Students use pauses to create interest and suspense.
 - Students develop and organize their presentations for a specific purpose, audience or task. (CCSS.ELA-LITERACY.SL.9-10.4)
 - Students strategically use digital media. (CCSS.ELA-LITERACY.SL.9-10.5)

6. Reflect on the content of the mini presentations.
 - *Why do we, as engineers, need to reflect on our presentation skills?* (Possible answers include: so we can convince others to listen to our ideas, so we can get new customers, so we can get feedback and make our ideas better.)
 - *What ideas did we hear in the presentations for new iterations?*
 - *Why is it important to think about iterations? Why don't we stop with the first prototype?* (Possible answers include: we can always learn more and try new things, any final product goes through editing/refining/iterating before it is refined and ready to be released.)
7. Next steps
 - *Your teams have designed a prototype solution and presented your findings to the class. We are going to practice these skills in a second design challenge. After that we are going to design and present our learnings as a panel of volcanologists.*
 - *What questions do you have about what we have already done and where we are going?*

D. Iterating the Design Solution (35 minutes)

1. Introduce the second design challenge.

Design Problem:

- Justin Case has made it to safety and now receives a satellite phone call from the last member of the team, Justin Time. He is trapped in a similar situation and it is up to your team to talk Justin Time through how to escape to safety so your whole team can make it to your interview next week.

Criteria (Design Requirements/Desired Features):

- Transport "Justin Time" figure from Tree A to Tree B without touching the lava.
- Students will document their solutions by drawing them and labelling the components.

Constraints (Design Limitations):

- Budget: Justin Time only has 4 items in his backpack; 3 of the items are the same as those in the team's backpack and 1 item is a component the team hasn't used. Each team will decide what 4 things are in Justin's backpack.
- Schedule: Your team has 5 minutes to brainstorm and 15 minutes to create and test your device before the tree falls into the lava.
- When testing their solution, students may not reach their bodies beyond Tree A, it is too far for Justin Time to reach or jump to Tree B.

Testing:

- Your team will test their designs at the rig to see how well their solution performs.

Role of Audience Members

Each member of the audience will:

- Analyze each presentation for how it meets the class list of presentation skills.
- Compose one post-it note to each team telling them one thing they did well in their presentation.
- Create follow-up questions to ask at the end of the presentations to help teams clarify their ideas.



2. Imagine possible solutions and create.
 - Have students brainstorm in their groups for 5 minutes before building.
 - Have students collect new materials, create a new prototype, and test on the rig for 15 minutes.
 - Ask groups facilitative questions to help students as they work:
 - *What components did you choose this time?*
 - *What ideas are you incorporating from the first design challenge?*
 - *Which part of your design are you most excited about? Why?*

3. Share solutions.
 - The class has had one share-out and one mini presentation. This time, students will have the opportunity to practice combining their device demonstration with a mini presentation.
 - Have students return to their seats and draw their second prototype on the back side of the Data Collection Worksheet.
 - Give teams 10 minutes to review their ideas from their individual data collection worksheets and prepare for a second mini presentation.
 - The presentations may include the following:
 - Introduce the team.
 - Identify the components in their design prototype.
 - Demonstrate their prototype up to 3 times on the rig.
 - Explain how their prototype addresses the criteria and constraints of the challenge.
 - Explain whether or not their second solution is more or less successful than their first.
 - Describe the changes the team would make for a second iteration of this design.
 - [6-8th] Explain the order of components in your prototype and why these choices were made.
 - Have student teams present for their classmates.

4. Reflect on the design challenge and the presentations
 - *Now you have created two design challenge solutions and you have given two team mini presentations.*
 - *Which presentation skills are you finding easier in the second iteration?*
 - *Which presentation skills do you still find difficult or want to keep practicing?*
 - [6-8th] *What is the effect of changing one part of the system? Does switching a component or the order of components matter? Why or why not?*

E. Evaluation (50-100 min)

1. Share the final assessment with the students. (Appendix E, "Final Assessment")

Final Presentation:

- *Now your team is back together and you are getting ready for your panel interview on volcanoes for the Discovery Channel. As a team you will need to put together a comprehensive presentation to share that describes the solution you designed for the engineering challenge.*

Criteria (Design Requirements/Desired Features):

Students will:

- Create at least one visual aid that is in color and includes clearly labelled components.
- [4-5th] Demonstrate the presentation skills they have been practicing as a class.
- [6-8th] Demonstrate the presentation skills they have been practicing as a class in addition to using appropriate eye contact, adequate volume, and clear enunciation.



- Incorporate the 5 engineering terms listed on the Final Assessment handout for the lesson. (The 5 engineering terms for this lesson are: components, system, prototype, diagram, iterate)
- Explain how their team used criteria and constraints in creating your prototypes.
- Describe how they used what they learned from the first design challenge in the second design challenge.
- Explain what their team would do if they had more time for another iteration.

Constraints (Design Limitations):

- Presentations must be between 7-10 minutes.
- Each team member must present a portion of the content in the presentation.
- Schedule: 30 minutes to create the visual aid and prepare for the presentation.

Role of Audience Members

- Ask questions to help teams clarify their ideas.
 - Record one positive about each team on a green post-it note to turn into you.
2. Review the rubric with students so they have a clear understanding of how their assessment is being graded. (See Appendix C, "Evaluating Student Learning using a Rubric.")
 - Ask students if they have any questions about the rubric or the assessment of the final presentation.
 - For more information on using rubrics see Appendix C, "Evaluating Student Learning using a Rubric".
 3. Give students the materials and 30 minutes to create their presentations and accompanying visual aids.
 4. Have student teams present to the class. Making this experience as authentic for the students as possible is highly encouraged. Some suggestions include:
 - Invite engineers, parents, other classes, or other interested parties so students can show their learning in front of a new audience.
 - Treat the presentations like a press conference by recording their performances.
 - Host a potluck at the end to celebrate the work the students have done.



IV. Appendices

A. Vocabulary

Term	Definition
analyze	To examine something in detail with the typical purpose being the ability to explain or interpret the information.
component	A part or element of a larger whole, especially a part of a machine.
constraint	The limitations of a design problem which typically include budget and schedule limitations but may also include other limitations such as maximum size restrictions.
criteria	The requirements or desired features of a design problem often describing the purpose and standards that a system or device must meet.
design problem	The identified challenge, goals, or needs that a design addresses. What you are trying to solve?
design process	A series of steps that engineers use to guide them as they solve problems. The process is nonlinear but cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way of imagining, creating, reflecting, testing and iterating. These are steps used to come up with solutions:
diagram	A simplified drawing showing the appearance, structure, or workings of something; a schematic representation.
engineer	A person who designs and builds innovative solutions (machines, systems, or structures) to solve a problem or meet a need.
engineering	The process that engineers go through to create, design, test, and build a solution.
evaluate	To form an idea of the amount, number, or value of; to assess.
evidence	The available information indicating whether a belief or proposition is true or valid.
failure point	A place where the design or system failed.
function	The action or purpose of an object including how it moves or interacts with other objects.
interaction	A reciprocal action or influence.





iteration	When you try different solutions (create, test, reflect, imagine) over and over.
load	Another word for force, or what the structure must hold up to. In a machine doing work, like simple machines, a load is the weight or mass being supported and/or moved.
optimal design	The design or device that best meets the criteria and constraints.
prototype	The models that you build to test before you get to your final solution.
sequence	A particular order in which related events, movements, or things follow each other.
structure	The material or arrangement of parts in an object to make up the whole.
system	A set of connected things or parts forming a complex whole.
trade-off	A situation in which you must choose between or balance two things that are opposite or cannot be had at the same time.



B. Resources

- Alber, Rebecca. "Say What? 5 Ways To Get Students To Listen." *Edutopia*. N.p., 2017. Web. 26 July 2017. <https://www.edutopia.org/blog/five-listening-strategies-rebecca-alber>
- Community, How et al. "Helping Students To Develop Presentation Skills - The Edvocate." *The Edvocate*. N.p., 2017. Web. 26 July 2017. <http://www.theedadvocate.org/helping-students-to-develop-presentation-skills/>
- "Keeping a Lab Notebook." *Gonzaga University*. N.p., n.d. Web. 28 Jul. 2017. http://www.gonzaga.edu/academics/colleges-and-schools/college-of-arts-and-sciences/majors-programs/Biology/Undergraduate_Research/student-research-tips/notebook.asp.
- "Kid President." Kidpresident.Com, 15 Sept.2017, <http://kidpresident.com>
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C. Background Information

Brainstorming

Getting ideas out of our heads and building on them with a team is one of the great strengths of group work. There are many web-based resources to explain techniques to maximize on effective brainstorming in the classroom. Here are a few if you want help, or want to try something new:

- Iowa State University “14 Creative Ways to Engage Students”
<http://www.celt.iastate.edu/teaching/teaching-format/14-creative-ways-to-engage-students>
- IDEO.org Design Kit “Brainstorm Rules”
<http://www.designkit.org/methods/28>

Engineering Design Process:

Introduce the engineering design process graphic with students to show how engineers engage in fun, creative, problem-solving that is core to their work.

- Explain to students that as engineers go about solving problems and coming up with creative and innovative solutions to challenges, they follow the **design process**.
 - **Design Process:** a series of steps that engineers use to guide them as they solve problems. The process is non-linear but cyclical, meaning that engineers can follow the steps in no particular order, repeat the steps as many times as needed, and make improvements along the way of imagining, creating, reflecting, testing and iterating.
- We represent this process with a graphic that shows the main steps someone goes through as they solve a problem.
 - Define your problems: What is the problem you are trying to solve? What are the criteria (design requirements that will determine the success of your solution)? What are the constraints (real-life limitations like budget and schedule) that you have to work within?
 - Test/reflect – imagine – create: This is the main part of the process that is cyclical. This is where engineers go through multiple designs as they have ideas, try something out, test it, have new ideas, and incorporate it all into more building and testing. This process can go through many rounds as an engineer gets more information from each test and design that is tried.
 - Sharing solutions: Engineering is about teamwork, and engineers frequently learn from each other as they solve problems. It’s important for students to communicate and share throughout the process so that—just like real engineers—they can learn from each other and improve their solutions. It’s particularly important to culminate a project with a formal sharing of solutions and perhaps even a showcase or other authentic ways to share lessons learned with the broader community (e.g. community members, family members, principal, younger students, etc.).
- When you see the design process in action, you’ll notice that it’s rarely the smooth succession of steps that the diagram implies. The steps often overlap and blur, and their order is sometimes reversed – it’s a creative, fluid way of working that must be adapted to each individual situation.
- As you guide students through the design process, you’ll want to be flexible and receptive to the different approaches your students may try.
- Ask students to notice where they are in the design process and even to trace their path through the steps, so they can see how messy it can be.



Evaluating Student Learning using a Rubric:

Review the rubric with students at the introduction of the project so they know what their learning goals are. It is important to allow students to begin with the end in mind, just as teachers “backwards plan”, using standards and assessments to inform units, topics, and day-to-day activities.

The rubric in the lesson guide is designed to evaluate student mastery of the “met” standards using the categories *Below Standard*, *Approaching Standard*, *Meeting Standard*, and *Above Standard*. This allows teachers to give individual feedback particularly for the students who are *Below Standard* or *Above Standard* in particular areas.

- In the Below and Above Standards sections of the rubric, the idea is that no student should be receiving these scores without personalized attention from the teacher – either as remediation or as extension to reach students where they are.
- With that in mind, the descriptions and observations in these two sections are simply examples of what you might see for students performing at that level. The comments and notes in these sections should be tailored to the specific student and should accompany individualized support and conversations.
- To learn more about Understanding by Design and rubrics, see ASCD’s Understanding by Design in the reference section.

Journaling

Science or engineer journaling can be a powerful learning tool for students. Encouraging students to use their writing skills across subjects and to use both graphic and written forms of expression can help integrate different learning styles. Below are some ideas on how to integrate journaling as a part of scientific discovery.

- “Keeping a Journal as a Scientific Tool” from Claudine Kavanagh on the Science Integration Institute <http://www.scienceintegration.org/Resources/journals.html>
- “Science Notebooks” by Carole Cox on Reading Rockets <http://www.readingrockets.org/article/science-notebooks>
- “Teaching Students to do Quality Work in Science Notebooks” by Ari Mosquera on The Science Penguin <https://www.youtube.com/watch?v=W1K08D2aMG4>

Scaffolding Strategies

Helping students access content and interact with new knowledge can often include scaffolding in your teaching practice. Here are two web based resources that have some tips and tricks for scaffolding in the classroom.

- “6 Scaffolding Strategies to Use With Your Students” by Rebecca Alber on Edutopia <https://www.edutopia.org/blog/scaffolding-lessons-six-strategies-rebecca-alber>
- “Scaffold Questions to Scaffold Answers” by Marzano Research Laboratory <https://soltreemrls3.s3-us-west-2.amazonaws.com/marzanoresearch.com/media/documents/ASOT-Gothenburg-NE-81214-60-120.pdf>



Teaching Presentations

Engaging audiences is a necessary skill in the classroom, boardroom, and on the playground. How does a teacher engage and encourage quality presentation skills in the classroom that will translate into real-life experiences? There are many resources and lesson plans designed to help a teacher do this in a wide variety of ways. Consider reviewing one of the following:

- “Using TED to Develop Presentation Skills” by Kate Perry based on the ideas of Marina Broeder
<http://www.thetechclassroom.com/home/usingtedtodeveloppresentationskills>
- “Teaching Presentation Skills” by Simon Parker of Albion International
<http://www.beta-iatefl.org/cogitoergosum/wp-content/uploads/2010/09/2008-Simon-Parker-Presentation.ppt>
- “TEDs Secret to Great Public Speaking” by Chris Anderson of TED
https://www.ted.com/talks/chris_anderson_teds_secret_to_great_public_speaking



D. References

- "14 Creative Ways to Engage Students." Iowa State University. Web. Accessed 23 Aug. 2017. www.celt.iastate.edu/teaching/teaching-format/14-creative-ways-to-engage-students
- Alber, Rebecca. "6 Scaffolding Strategies to Use With Your Students." Edutopia, George Lucas Educational Foundation, 24 May 2011. Web. Accessed 23 Aug. 2017 www.edutopia.org/blog/scaffolding-lessons-six-strategies-rebecca-alber
- Anderson, Chris. "TED's secret to great public speaking". TED TALKS. Mar. 2016. Web. Accessed 23 Aug. 2017. https://www.ted.com/talks/chris_anderson_teds_secret_to_great_public_speaking
- ASCD. "Understanding by Design®." Understanding by Design® framework - Videos, Articles, Resources, Experts. Web. Accessed 18 Aug. 2017. www.ascd.org/research-a-topic/understanding-by-design-resources.aspx
- "Brainstorm Rules." Design Kit, IDEO.org. Web. Accessed 23 Aug. 2017. www.designkit.org/methods/28
- Cox, Carole. "Science Notebooks." Reading Rockets, 2012. Web. Accessed 25 Aug. 2017. www.readingrockets.org/article/science-notebooks
- "Dawn of Fire." Hulett, Tyler. Producer. YouTube, YouTube, 26 Jan. 2017. Web. Accessed 5 Sept. 2017. www.youtube.com/watch?v=qA8D8e34LZc
- Kavanagh, Claudine. "Keeping a Journal as a Scientific Tool." Science Integration: Keeping a Journal, Science Integration Institute. Web. Accessed 25 Aug. 2017. www.scienceintegration.org/Resources/journals.html
- Mosquera, Ari. "Teaching Students to do Quality Work in Science Notebooks | The Science Penguin." YouTube, The Science Penguin, 14 July 2015. Web. Accessed 25 Aug. 2017. www.youtube.com/watch?v=W1K08D2aMG4
- Parker, Simon. "Teaching Presentation Skills." BETA, IATEFL Affiliate, 10 May 2008. Web. Accessed 23 Aug. 2017. wwwsw.beta-iatefl.org/cogitoergosum/wp-content/uploads/2010/09/2008-Simon-Parker-Presentation.ppt
- "Scaffold Questions to Scaffold Knowledge." Marzano Research, Marzano Research Laboratory. Web. Accessed 23 Aug. 2017. <https://soltreemrsls3.s3-us-west-2.amazonaws.com/marzanoresearch.com/media/documents/ASOT-Gothenburg-NE-81214-60-120.pdf>
- "Using TED to Develop Presentation Skills - The Tech Classroom." *Thetechclassroom.com*. N.p., 2017. Web. 26 July 2017. <http://www.thetechclassroom.com/home/usingtedtodeveloppresentationskills>
- "Villarrica volcano eruption puts Chile on alert." BBC News, BBC. Web. Accessed 5 Sept. 2017. www.bbc.com/news/av/world-latin-america-31705977/villarrica-volcano-eruption-puts-chile-on-alert



E. Lesson Handouts

Handout Title	Page
Engineering Design Process <i>Graphic representing the design process</i>	22
Data Collection: How We Escaped the Lava [4-8 th grade] <i>Data collection for Part B and Part D</i>	23
Discovery Channel Panel on Volcanology [4-5 th grade] <i>Final Assessment planning document</i>	24
Discovery Channel Panel on Volcanology [6-8 th grade] <i>Final Assessment planning document</i>	27
How We Escaped the Lava Rubric [4-5 th grade] <i>Rubric for assessing student mastery and progress on standards</i>	30
How We Escaped the Lava Rubric [6-8 th grade] <i>Rubric for assessing student mastery and progress on standards</i>	32



Engineering Design Process and Innovator Mindsets





Name: _____

Date: _____ Class: _____

Data Collection: How We Escaped the Lava

Each sketch should include the following:

- A. Diagram your device to show how it is used to transport Justin Case get from one tree to the other.
- B. Label all of the components.
- C. Label any failure points.

Date:	Prototype #:	Name:
Criteria and constraints this solution DOES meet:	Criteria and constraints this solution DOES NOT meet:	

To improve on our prototype, some improvements we can make are:



Expedition Channel Panel on Volcanology

Final Assessment [4-5th grades]

Your team is back together and you are getting ready for your panel interview on volcanoes for the Expedition Channel. As a team, you will need to put together a comprehensive presentation where every member shares something about the team’s prototypes.

What should my team do to prepare?

- Give every member a speaking part.
- Divide up questions to address in your presentation.
- Decide the order in which each team member will speak for the panel discussion.
- Practice presenting with a focus on your team’s presentation skills (practice, practice, practice).
- Time your practice presentations to make sure you are in the 3-4 minute zone.

What should your team talk about in their presentation?

1. Introduce your team.
2. Showcase your engineering vocabulary by incorporating all 5 of these words into your presentation.
 - a. Components
 - b. System
 - c. Prototype
 - d. Diagram
 - e. Iterate
3. Create a visual aid for the presentation that is:
 - a. Final Draft quality (This means: colored in, aids in telling your story, and has no spelling errors)
 - b. Clearly labelled components
4. Which presentation skills is your team going to showcase? Pick three from our classroom chart:



5. How did your team solve both design challenges within the criteria and constraints?

Challenge 1:

Challenge 2:

6. What did you learn through your iterations that led to the second prototype design?

7. What would your team do in your next iteration, if you had more time? Why?

8. Which presentation skills were the most valuable in your presentation?



Name: _____

Date: _____ Class: _____

9. Conclusion. What final thoughts will you share with the viewers of Expedition Channel's Volcano Week?

10. Open up the panel discussion to questions.



Expedition Channel Panel on Volcanology

Final Assessment [6-8th grades]

Your team is back together and you are getting ready for your panel interview on volcanoes for the Expedition Channel. As a team you will need to put together a comprehensive presentation where every member shares something about the team prototypes.

What should my team do to prepare?

- Give every member a speaking part.
- Divide up questions to address in your presentation.
- Decide the order in which each team member will speak for the panel discussion.
- Practice presenting with a focus on your team’s presentation skills (practice, practice, practice).
- Time your practice presentations to make sure you are in the 3-4minute zone.

What should your team talk about in their presentation?

1. Introduce your team.
2. Showcase your engineering vocabulary by incorporating all 5 of these words into your presentation.
 - a. Components
 - b. System
 - c. Prototype
 - d. Diagram
 - e. Iterate
3. Create a visual aid for the presentation that:
 - a. Is Final Draft quality (This means: colored in, aids in telling your story, and has no spelling errors).
 - b. Has clearly labelled components
4. Which presentation skills is your team going to showcase? Pick three from our classroom chart in addition to **appropriate eye contact, clear enunciation, and adequate volume:**



5. How did your team solve both design challenges within the criteria and constraints?

Challenge 1:

Challenge 2:

6. What did you learn through your iterations that lead to the second prototype design?

7. What would your team do in your next iteration if you had more time?

8. What has your team learned about making changes to a system? How does changing the order or the components of the prototype impact the solution overall?



Name: _____

Date: _____ Class: _____

9. Conclusion. What final thoughts will you share with the viewers of Expedition Channel's Volcano Week?

10. Open up the panel discussion to questions.



4-5th Grade Rubric

	Below Standard	Approaching Standard	Meeting Standard	Above Standard
<p>Common Core ELA CCSS.ELA-LITERACY.CCRA.SL.4</p> <p>Present information, findings, and supportive evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.</p>	<p><i>Areas that individual students may need one-on-one support with:</i></p> <ul style="list-style-type: none"> • Explaining the logical sequence of their design challenge. • Making iterations to their design. • Motivating group members to participate in oral presentation. • Presenting clearly and concisely. 	<ul style="list-style-type: none"> • Presentation provides a clear explanation of how one of the team's prototypes addressed the criteria and constraints of one of the design challenges. • All team members are present but the presentation either needs more explanation or provides too much information. • Team's presentation demonstrates two or more presentation skills from the class chart. • Presentation includes 2-3 key engineering vocabulary terms for this lesson. 	<ul style="list-style-type: none"> • Presentation provides a clear explanation of how both the team's prototypes addressed the criteria and constraints of the design challenges. • Each team member presents some aspect of the presentation and the whole team's presentation is in time allotted and provides appropriate information. • Team's presentation demonstrates mastery of three or more presentation skills from the class chart. • Presentation includes 4-5 of the key engineering vocabulary words for this lesson. 	<p><i>Areas where students may exceed:</i></p> <ul style="list-style-type: none"> • Explain at least 3 iterations of their design with evidence to support the changes. • Findings are presented succinctly and clearly, allowing the audience to easily follow the line of reasoning. • Presentation includes more than the 5 key engineering terms. <p><i>Ideas for next steps for growth:</i></p> <ul style="list-style-type: none"> • Provide peers with strategies for speaking in front of an audience. • Create a multimedia presentation. • Research an area of engineering that relates to the challenge and includes it in their presentation.



<p>NGSS Science and Engineering Practices (SEP) Obtaining, evaluating, and communicating information: Communicate scientific and/or technological information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts</p>	<p><i>Areas that individual students may need one-on-one support with:</i></p> <ul style="list-style-type: none"> Sequencing the data collection in a logical and chronological way to communicate the design process. Identifying failure points that can be improved upon; understanding iteration process. Including diagrams/pictures/tables that demonstrate the trial and error process. 	<ul style="list-style-type: none"> Each student has 2 partially completed prototype designs that are labelled with components and ideas for the next iteration. Failure points may be identified but steps were not made to strengthen these areas. Visual aid used in the presentation is not of final draft quality (not colored in, labelled correctly, or there are spelling errors). 	<ul style="list-style-type: none"> Each student has 2 complete prototype designs that are labelled with components and ideas for the next iteration. Failure points are clearly identified and improved upon through 1 iteration in the data collection journal. 1 final draft, colored, presentation quality visual aid is shown during the presentation that clarifies information in the presentation. 	<p><i>Areas where students may exceed:</i></p> <ul style="list-style-type: none"> The data collection provides a high level of detail through images and/or labels. At least three iterations are depicted in diagrams/pictures/tables with clear labels of all components, failure point(s), and ideas for more development in iterations. Presentation includes 2 or more high quality visual aids that help illustrate key ideas in the presentation. <p><i>Ideas for next steps for growth:</i></p> <ul style="list-style-type: none"> Identifying failure points and addressing them throughout the design process to strengthen the overall design.
<p>NGSS Crosscutting Concepts (CCC) Systems and System Models: A system can be described in terms of its components and their interactions</p>	<p><i>Areas that individual students may need one-on-one support with:</i></p> <ul style="list-style-type: none"> Explaining how the items work with each other Explaining how the items aided the completion of the design challenge Explaining what iteration(s) were made based on trial/error. 	<ul style="list-style-type: none"> Team presentations clearly explain how the components of 1 prototype work together as a system to solve the design challenge. <p>OR</p> <ul style="list-style-type: none"> Partially able to explain how the items aided the completion of the design challenge for both challenges. 	<ul style="list-style-type: none"> Team presentations clearly explain how the components of both prototypes work together as a system to solve the design challenge. 	<p><i>Areas where students may exceed:</i></p> <ul style="list-style-type: none"> Thoroughness and detail of explanation of the interaction of the components. Thoroughness and detail of explanation of how the components aided the completion of the design challenge. <p><i>Ideas for next steps for growth:</i></p> <ul style="list-style-type: none"> Create a book that includes more detail about the interaction of the components and how they aid in the completion of the design challenge.



6-8th Grade Rubric

	Below Standard	Approaching Standard	Meeting Standard	Above Standard
<p>Common Core ELA CCSS.ELA-LITERACY.SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.</p>	<p><i>Areas that individual students may need one-on-one support with:</i></p> <ul style="list-style-type: none"> Explaining the logical sequence of their design challenge. Making iterations to their design. Motivating group members to participate in oral presentation. Presenting clearly. Presenting with eye contact, appropriate volume, or clear enunciation. 	<ul style="list-style-type: none"> Presentation provides a clear explanation of how one of the team's prototypes addressed the criteria and constraints of one of the design challenges. All team members are present but the presentation either needs more explanation or provides too much information. Team's presentation demonstrates two or more presentation skills from the class chart. Presentation includes 2-3 key engineering vocabulary terms for this lesson. The team presents relevant content, but it is not organized in a way that is easy for the audience to understand or it is missing support for the main ideas. 	<ul style="list-style-type: none"> Presentation provides a clear explanation of how both of the team's prototypes addressed the criteria and constraints of the design challenges. Each team member presents some aspect of the presentation and the whole team's presentation is in time allotted and provides appropriate information. Team's presentation demonstrates mastery of three or more presentation skills from the class chart AND the presenters use appropriate eye contact, volume, and clear pronunciation. Presentation includes 4-5 of the key engineering vocabulary words for this lesson. Teams provide a logically organized presentation with appropriate supporting details. 	<p><i>Areas where students may exceed:</i></p> <ul style="list-style-type: none"> Explain at least 3 iterations of their design with evidence to support the changes. Findings are presented succinctly and clearly, allowing the audience to easily follow the line of reasoning. Presents using more than the 5 key engineering terms. <p><i>Ideas for next steps for growth:</i></p> <ul style="list-style-type: none"> Provide peers with strategies for speaking in front of an audience. Create a multimedia presentation. Research an area of engineering that relates to the challenge and includes it in their presentation.



<p>NGSS Science and Engineering Practices (SEP) Obtaining, evaluating, and communicating information: Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.</p>	<p><i>Areas that individual students may need one-on-one support with:</i></p> <ul style="list-style-type: none"> • Sequencing the data collection in a logical and chronological way to communicate the design process • Identifying failure points that can be improved upon; understanding iteration process • Including diagrams/pictures/tables that demonstrate the trial and error process • Learning and aid in pronouncing scientific and engineering terms. 	<ul style="list-style-type: none"> • Each student has 2 partially completed prototype designs that are labelled with components and ideas for the next iteration. • Failure points may be identified but steps were not made to strengthen these areas. • Visual aid used in the presentation is not of final draft quality (not colored in, labelled correctly, or there are spelling errors) • Student presents a portion of the presentation, but does not use all of the vocabulary words correctly. 	<ul style="list-style-type: none"> • Each student has 2 complete prototype designs that are labelled with components and ideas for the next iteration. • Failure points are clearly identified and improved upon through 1 iteration in the data collection journal • 1 final draft, colored, presentation-quality visual aid is shown during the presentation that clarifies information in the presentation. • Each student presents a portion of their team's final presentation using the identified vocabulary terms. 	<p><i>Areas where students may exceed:</i></p> <ul style="list-style-type: none"> • The data collection provides a high level of detail through images and/or labels. • At least three iterations are depicted in diagrams/pictures/tables with clear labels of all components, failure point(s), and ideas for more development in iterations. • Presentation includes 2 or more high-quality visual aids that help illustrate key ideas in the presentation. <p><i>Ideas for next steps for growth:</i></p> <ul style="list-style-type: none"> • Identifying failure points and addressing them throughout the design process to strengthen the overall design.
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<p>NGSS Crosscutting Concepts (CCC) Systems and System Models: Systems may interact with other systems; they may have sub-systems and be a part of larger complex system.</p> <p>Stability and Change: Small changes in one part of a system might cause large changes in another part.</p>	<p><i>Areas that individual students may need one-on-one support with:</i></p> <ul style="list-style-type: none"> • Explaining how the items work with each other. • Explaining how the items aided the completion of the design challenge. • Explaining what iteration(s) were made based on trial/error. • More time needed experimenting with components to see how a system can be effected. 	<ul style="list-style-type: none"> • Team presentations clearly explain how the components of 1 prototype work together as a system to solve the design challenge. <p>OR</p> <ul style="list-style-type: none"> • Partially able to explain how the items aided the completion of the design challenge for both challenges. 	<ul style="list-style-type: none"> • Team presentations clearly explain how the components of both prototypes work together as a system to solve the design challenge. • Students can explain how changes in components or the order of components impacts the overall effectiveness of their solution. 	<p><i>Areas where students may exceed:</i></p> <ul style="list-style-type: none"> • Thoroughness and detail of explanation of the interaction of the components. • Thoroughness and detail of explanation of how the components aided the completion of the design challenge. <p><i>Ideas for next steps for growth:</i></p> <ul style="list-style-type: none"> • Create a book that includes more detail about the interaction of the components and how they aid in the completion of the design challenge.
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