Engineering Design Challenge

Topic: Engineering Design

Grade Level: 7/8

Time: 6 weeks

CCSS:

ELA/Literacy

WHST.6-8.2.A	Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
WHST.6-8.2.F	Provide a concluding statement or section that follows from and supports the information or explanation presented.
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
WHST.6-8.8	Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics

Math.Practice.MP1	Make sense of problems and persevere in solving them.
Math.Practice.MP4	Model with mathematics.
Math.Content.7.G.A.1	Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
Math.Content.7.G.A.2	Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions
Math.Content.8.G.A.1	Verify experimentally the properties of rotations, reflections, and translations:
Math.Content.8.G.A.1.A	Lines are taken to lines, and line segments to line segments of the same length.
Math.Content.8.G.A.1.B	Angles are taken to angles of the same measure.
Math.Content.8.G.A.1.C	Parallel lines are taken to parallel lines.

<u>NGSS:</u>

<u>Design & Technology</u>

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Learning Objectives:

- Students will define criteria and constraints of a real-world design problem.
- Students will gather relevant information from print and digital sources to serve as research based on self-generated questions to promote further exploration.
- Students will develop a solution model to generate data for iterative testing and modification of a chosen design problem.
- Students will improve upon their design by testing and analyzing their design solutions to better meet their established criteria.
- Students will construct appropriately scaled 2D drawings and blueprints to support their design problem solution.
- Students will use computer-aided drafting software to model solutions in 2D and 3D and verify geometric properties of rotations, reflections, and translations.
- Students will introduce a topic (design solution) clearly, previewing what's to follow, organize ideas, concepts, and information including formatting (e.g., headings), and graphics (e.g., charts, tables) on a display board to present at an Engineering Fair.
- Students will provide a concluding statement in the form of a reflective evaluation that follows from and supports the information or explanation presented at the Engineering Fair.

Driving/Essential Question:

How can the engineering design process benefit us in solving problems in our daily lives?

Prior Knowledge:

Students utilized the engineering design process to design and manufacture various projects in Pre-Engineering I. The multi-faceted engineering design process gave my students a base knowledge for brainstorming, conducting research, drafting (physical and computer-aided), 2D and 3D modeling, problem solving, and teamwork. They also applied safe practices while using hand tools and power tools to build their prototypes.

Justification:

In Pre-Engineering I (prerequisite to Pre-Engineering II) students designed and manufactured specific projects based on instructor specified criteria and constraints. Previous students have mentioned in their class reflections that they would like more choice in the types of projects that they get to design and build. This lesson will give students an opportunity to apply their creativity and all the skills acquired from Pre-Engineering I to design and manufacture problem solving solutions for real world problems, of their own choosing, through an open-design concept. By allowing them to choose their own real world problems to solve, the lesson immediately becomes relevant and interesting. As student engineers, they will learn and apply scientific principles, modern technology, engineering design concepts, and mathematics to make a difference in their life and or the lives of others. Specifically, students will use science for generating questions through observation and analysis and through scientific investigations to answer specific questions or inquires that can't be answered through research. Technology will be integrated with computer aided drafting software, 3D printers, digital Gantt charts, and machine shop equipment (saws, sanders, drills, etc.). Engineering provides the students with a step-by-step process to guide them from a problem to a solution. Lastly, students will use mathematics, through scale and measurement, for creating blueprints and building models.

Materials:

- **Composition Notebook**
- **Pencil**
- **Eraser**
- **Graph Paper**
- **Ruler**
- **Compass**
- **Computer**
- **Drafting Software**
- **3D Printer (optional)**
- **Cutting Tools (scissors, saws, etc.)**
- **Hand Tools (hammers, screw drivers, etc.)**
- **Fasteners (glue, screws, nails, etc.)**
- **Household Building Materials (cardboard, Styrofoam, wood, etc.)**

Vocabulary:

- Innovation
- Invention

- Gantt Chart

Engage: The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.

Day 1: (Watch Video's / Connection Circle)

This lesson will begin with a short video (6 minutes) that shows how peoples' lives have been made easier or better through the use of student made inventions and innovations. The purpose of showing this video is to inspire the students to want to make a difference in their life or in the lives of others by designing and building their own problem solving solution to an everyday problem.

Video Link: https://www.youtube.com/watch?v=FJQ-ddCGPAE

After watching the video give the students about 10 to 15 minutes to provide a written response to the following questions. The questions can be posted on the board with the intent that students will record their responses on their own paper or a worksheet can be made prior. Let the students know that they will be sharing their responses with the class in a connection circle.

Video Response Questions:

1. Choose a story from the video and describe how their invention or innovation made someone's life easier or better.
2. Describe a time when you or someone you know solved a problem to make someone's life easier or better.
3. Connect your story or a story from the video to the engineering design process.
4. Elaborate on what it means to be an engineer.
5. Would you consider the students in these videos to be engineers? Why or Why Not?

Connection Circle:

Once the students have completed their responses get them into a large connection circle. A connection circle gives everyone, including the instructor, an opportunity to share and be heard on any given topic. The circle starts with the instructor reading the first question, responding to it to set the tone, and then passing a talking piece (small physical object), to their left or right. The only person that is allowed to speak is the one who is holding the talking piece. If someone wishes to comment or ask a question based on someone's response they must raise their hand and be called on by the speaker or the instructor. Once everyone has had the opportunity to share their response to the first question the instructor reads the next question and continues the process. For this particular connection circle only questions 1, 2, and 5 will be used. At the end of the class all written responses will be turned in to formally assess student understanding on how the engineering design process benefits us in solving problems in our daily lives.

Day 2: (The Engineering Design Challenge / Grading Criteria / Set up Engineering Notebook / Eliciting Ideas Assignment)

The Engineering Design Challenge:

On day two, each student will be given a design brief that presents them with the design challenge and all the necessary dates and details to successfully complete that challenge. The students, in teams of 2 to 4, will design and create a solution to an everyday problem in their life, their community, or their school by way of the engineering design process. They will construct a solution model that is accurately fabricated to their design specifications, is fully functional, and suitable for design verification. The materials should be raw materials found around the house and/or purchased at a store. Students will have 3D printers, computers, and a machine shop to support the designing and building of their solution model. Lastly, they will present their design process and final solution at the first semi-annual school engineering fair. The engineering fair will be a gathering of parents, community members, local engineers, teachers, and administration.

Grading Criteria:

Included with the design brief is a chronological grading rubric (see attachment) that will serve as a progress status check and as a formative assessment tool. Each time the students complete a checkpoint task in the design process (stated below under Gantt Chart) the students will present the teacher with all supporting documents or evidence that demonstrates their understandings and completion of the task. The instructor will use the grading rubric to assess their progress and understandings and provide immediate feedback so the students can decide how best to proceed.

Setting up the Engineering Notebook/Journal:

We will start this project by setting up our engineering notebooks. Their notebooks will contain a detailed

account of every step of their project, from the initial brainstorming to the final data analysis. They will create a record of their project documenting exactly what they did and when they did it. They'll be able to look back at their notes anytime a question arises. Writing down their design ideas, challenges, and testing data will help them keep track of all their ideas, what they have already tried, and how well a particular design performed. The instructor will also conduct a weekly notebook check to verify compliance and provide necessary feedback. Their notebook will be organized with four main parts as indicated on the Engineering Notebook/Journal Format resource page (see attachment).
Note: Every student will have their own notebook but each team will present only one notebook at the engineering fair.

Eliciting Ideas Assignment:
Once students have finished organizing their notebooks give them the eliciting ideas resource page (see attached). This resource provides six different brainstorming topics with tips and examples to help students elicit invention and innovation ideas. Each student will keep a journal, using the "Define a Need" page of their notebooks to jot down any ideas that come to mind over the next few days. They can use the remainder of this period to start this assignment.

Day 3 & 4: (Gantt Chart)
Gantt Chart:
While students continue to brainstorm ideas for invention and innovation they will also need a tool to keep them on pace to finish by the deadline. We will incorporate some organizational technology in the form of a student created Gantt chart. A Gantt chart will provide the students with a graphical illustration of a schedule that will help them to plan, coordinate, and track the necessary tasks and check points associated with this project. We will create our Gantt charts using google sheets so all team members can access and edit the same document with ease. I'm anticipating that this chart will take two days to create and customize. We will use the following online resource to assist us in making the Gantt chart:
http://www.hellotecho.com/how-to-create-a-simple-gantt-chart-with-google-sheets

The following check point tasks will be added to our Gantt chart:

1. Define the Need (Problem Statement)
2. Research (Criteria and Constraints)
3. Research (Background Knowledge - 3 source

8. Construct Prototype
9. Testing Data and Analysis
10. Redesign (Prototype Improvement Plan with

minimum)

4. Brainstorming Possible Solutions (2-3 ideas with details)
5. Formulate a Solution (Scaled Blueprint and CAD Design)
6. List of Materials
7. Step-by-step procedures

detailed sketches)

11. Retesting Data and Analysis
12. Conclusion
13. Display Board
14. Interview Preparation for Engineering Fair

<u>Day 5: (Eliciting Ideas – School Tour & Research, Share Ideas - Connection Circle)</u>

<u>Eliciting Ideas:</u>

In order to keep the flow of ideas through invention and innovation going day five will provide in-class time for the students to continue eliciting ideas. Start by taking the students on a 15 minute tour, through the eyes of an engineer, of the school building both inside and out. Make sure the students bring their journals. This tour may spark some creativity and imagination to improve the school. During the next 15 minutes instruct the students to look for more ideas on the internet, encouraging them to also think about ways they can make positive change in the local community. While they are searching for additional ideas give each student an exit slip and ask them to jot down three design ideas that they are considering for their project. This exit ticket will be collected at the end of the following connection circle.

<u>Connection Circle:</u>

The remainder of the class period will be devoted to sharing their invention and innovation ideas in a connection circle. This will give the students an opportunity to hear what other students are interested in as well. While engaging in this connection circle, students will be asked to jot down any additional ideas that were shared in the circle that peak their interest onto the back of their exit slip.
Collect their exit slip at the end of the period and use this information to create a graphic organizer of each student and their interests to assist in the forming of teams on the following day.

Explore: The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.

<u>Week 2: (Form Teams, Determine problem or opportunity, Determine Specifications and limitations, Research, Student Investigations, STEM connections)</u>

<u>Forming Teams:</u>

Provide students with the student interest graphic organizer and about 10 - 15 minutes to form teams of 2 to 4 based on their common interests. It is also allowable for students to work alone if their idea is unique from the rest of the class. Once the teams have been formed and grouped together they will be given the remainder of the period to explore their problem or opportunity and to begin constructing their problem statement.

Constructing a Problem Statement:

A problem statement gives a clear concise description of the issue(s) that need(s) to be addressed by each problem solving team. It should be used to center and focus the team at the beginning, keep the team on track during the effort, and be used to validate that the effort delivered an outcome that solves the problem statement. The problem statement should have a vision, (what does the world look like if we solve the problem?), an issue statement (one or two sentences that describe the problem using specific issues), and a method (the process that will get followed to solve the problem). Suggest to the students that answering the 5"W"'s (Who, What, When, Where, and Why) is a great strategy for getting pertinent information out for discussion.

Who – Who does the problem affect? (Specific groups, organizations, customers, etc.)
What – What is the issue? What is the impact of the issue? What impact is the issue causing?
When – When does the issue occur? When does it need to be fixed?
Where – Where is the issue occurring?
Why – Why is it important that we fix the problem?

Conduct Research - Establishing Criteria, Constraints, and Background Knowledge:

Once the problem statement has been created, the team is ready to conduct research. This research may include reading articles in books, magazines, or on the internet to assist in formulating ideas and recognizing constraints for their designs. Students may also examine existing designs to help them to establish criteria and formulate important questions. Examples may include measurement (how long, how heavy, etc.), performance (how fast it moves, how high it goes, how much it can hold, and so forth), how it will be used, its durability (how long it will last), or how much energy it uses. Students may also want to look at history, properties of materials, science principles, facts, or any other information that may seem relevant. At least three sources must be used for the research. Students will finish this step by writing a summary of what they learned from the research and by compiling a clear list of criteria and constraints related to the problem.

Scientific Investigation(s):

A team may also find it helpful to perform a scientific investigation to answer specific questions or inquiries that couldn't be answered through research alone. For example, students could set up an experiment to determine how much weight certain materials of certain sizes can withstand before they flex or break? All scientific investigations must be approved by the instructor and recorded in the research and investigation pages of the engineering design notebook.

Week 3: (Brainstorm Possible Solutions, Formulate a Solution to implement (materials list, procedure, blueprint))

Brainstorm Possible Solutions:

Once the team has a good understanding of their design challenge, established criteria and constraints, and background research - they are ready to begin the process of thinking about solutions to the challenge. Brainstorming is a team creativity activity that helps to generate many possible solutions to the challenge. It's important that all members of the team keep an open mind and encourage all ideas no matter how crazy they may seem. The design solutions being considered by the team must establish all the requirements needed for the development of the prototype, including detailed sketches and labels, to decide how it will be built. Typical requirements relate to shape, size, weight, appearance, physical features, performance, use, cost, time and money. The students should also write down the prototype expectations and how it will be tested to meet the desired expectations.

Formulate a Solution to Implement:

The next step in the design process is to formulate a solution to implement. This step is typically the hardest step. Students will revisit the needs, constraints and research from earlier steps, compare their best brainstorming ideas, select one solution and make a plan to move forward with it. Students should consider aesthetics, cost, available resources, time, skills required, and safety as additional criteria for their decision. The chosen solution must include a scaled blueprint (1:1 or smaller) with precise measurements and a detailed description that clearly explains how the solution best meets the need that was identified at the beginning of the design process. Another part of implementing a solution is to make a list of materials and equipment that they will use for building their prototype. This list needs to use descriptive works to describe the materials and equipment. Any materials that are measured should have the measurements listed. Lastly, the team will need to write a step-by-step procedure that they will follow to build their prototype. It's important that the step-by-step procedure also be very descriptive.

Week 4: (Build Prototype & Test Solution)

Build Prototype:
At this point in the design process, the team builds their prototype according to their design requirements, list of supplies and equipment, and their step-by-step procedure. Depending on the nature of the problem, the model may be full size or a scale model. The model may also be a working model; a critical portion of the model may be a working part; or it may just be a model to determine size, fit, or compatibility. The prototype or model is intended to provide feedback (positive or negative) regarding the proposed solution. In addition to building the prototype the students will need to write about the experience of building the prototype in their notebook.

Test Solution:
Once complete students will test their solution, which in most cases is the model, in an appropriate fashion to determine durability, ease of use, aesthetics, adherence to specifications functionality, and other characteristics that depend on the nature of the problem. These results of the tests are recorded as both observations (what's actually happening) and data (time, distance, cost, temperature, volume, and so forth). These results will need to be accurately recorded using data tables for further analysis.

Elaborate/Extend: The purpose for the EXTEND stage is to allow students to use their new knowledge and continue to explore its implications.

Week 5: (Analyze test results & improve upon or redesign solution)

Analyze Test Results:
To analyze the results, students will need to look at them in a way that helps them see the observations and data in an organized fashion. Students will analyze their data with graphs, spreadsheets, or logical reasoning. Analyzing test results also involves asking and answering questions based on the data and observations made. Did our design work the best that it could? How could we make it better? Is it

practical? Are the materials cheap and easy to find? Does our solution create new problems, or the need for another new product? Will others be able to use it equally as well? They must also understand that a successful prototype is not necessarily one without problems, but one that will help them to refine their design.

Redesign:

Upon completion of the first tests students may need to make adjustments by redesigning parts of the prototype that need adjusting. They will need to show the adjustments with diagrams and labeling. Keeping accurate notes of the changes is very important in this part of the engineering project. Additionally, retesting is also necessary after redesigning has occurred. The observations and data from retesting must also be recorded. Students must then analyze the new data and determine if the results match their design requirements. If not, redesigning is necessary.

Explain: The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means.

Conclusion:

Once the students feel that the prototype has reached its greatest effectiveness according to the design requirements they can move on to the conclusion. When writing their conclusion they need to show evidence of what was learned. The conclusion summarizes the learning by answering some of these questions: How do the results validate what was expected to happen? What was learned from building the prototype? In what ways is the prototype important? Are there more things that could be done to improve the prototype? How does this prototype help people understand the world better? How can this information be applied to real life? What new insights were discovered? What knowledge was gained by designing and building the prototype? The conclusion needs to show the value of the project and the prototype and how it can apply to life and/or the real world. Write about the final prototype by looking at its merits, originality, and usefulness.

Week 6: (Prepare Display Board and Prep for Engineering Fair Presention/Interview)

Share Solution – Engineering Fair:

The final week will be devoted to making preparations for the community engineering fair where students will explain what they learned. Each team will make a display board that clearly communicates each step of the design process including: a problem statement, criteria and constraints, a design statement, preliminary and final design descriptions, illustrations and sketches, building pictures, testing results and analysis, and their conclusion statement. The engineering design notebook and model solution will also accompany the display board for the presentation. A sample project display model can be found on the following site:

https://science-fair.org/students-parents/project-display-rules/

In addition to preparing the display board, students must also prepare for the interview that will take place at the engineering fair. The attendees (community members, engineers, and teachers) will want to know how much they know about their project. Encourage the students to be excited about their project when they speak. Students should be prepared to elaborate on their answers while showing depth of knowledge with clear and concise answers. To better prepare the students for their interview they will be provided with the following list of questions ahead of the fair. Additionally, the attendees of the fair will be provided with these guiding questions to assist in a well-rounded discussion.

- Explain where you got your idea for the project.
- What did you do to personalize it and make it unique?
- Explain the project method you used
- Why did you choose this problem to solve?
- Explain your results.
- Explain your conclusion.
- How does the result relate to your background knowledge?
- How does the result help you in understanding the world better?
- How does your project have practical applications?
- Specific background knowledge about your topic.
- What problems did you run into?
- How could you have improved your project?
- If you did it again, what would you change?
- What questions do you have now?
- Tell some ideas you learned from your research?
- How did the research help you with your project?
- How did others help you or give you ideas?
- How did you test your prototype?

Evaluate: The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place.

The engineering fair provides an opportunity for the students, the instructor, and any other attendees to evaluate the learning that has taken place through the engineering design challenge. The interviews taking place during the engineering fair will test the student's ability to communicate their understanding of the design process and its applications to solve problems. It will also give the students an opportunity to get additional feedback to promote further questioning and learning about their project. You, as their

instructor will also interview each team to better understand what they've learned from this challenge. You will evaluate your students using the original engineering design grading rubric and all the evidence (visual and verbal) presented at the engineering fair. The students will also reflect on their learning and evaluate themselves using the same rubric and criteria at the end of the engineering fair.
References: 10 Genius Kid Inventions That Made MILLIONS. YouTube, 20 June 2018, www.youtube.com/watch?v=FJQ-ddCGPAE Inventions-Handbook, (2011-2015). Looking for Easy and Creative Invention Ideas for Kids. Retrieved from www.inventions-handbook.com/invention-ideas-for-kids.html Media in Bloom., (2015-2018). Synopsys Science & Technology Championship. Project Display Rules. Retrieved from https://science-fair.org/students-parents/project-display-rules/ Stepniewski, D., (May 9, 2014). How to Create a Simple Gantt Chart with Google Sheets. Theme Horse. Retrieved from http://www.hellotecho.com/how-to-create-a-simple-gantt-chart-with-google-sheets

Grading Rubric

Requirement	**Advanced (4)**	**Proficient (3)**	**Partially Proficient (2)**	**Unsatisfactory (1)**
Identify the Need or Problem (Problem Statement)	• The problem is identified and explained with an elevated description of the issue(s) that need(s) to be addressed.	• The problem is identified and explained in detail.	• The problem is unclearly stated or some details are missing.	• The problem is not identified and/or explained.
Criteria and Constraints	• All criteria and constraints are listed and clarified.	• All criteria and constraints are listed.	• Some criteria and constraints are listed.	• Criteria and constraints are inappropriate or missing.
Research	• Research is clearly	• Research is	• Research is	• Research is missing or

	documented with labels. • Research is appropriate, and significant to the stated need or problem.	documented. • Research is appropriate, and significant to the stated need or problem.	documented. • Research is somewhat appropriate and/or significant to the stated need or problem.	minimally documented. • Research is inappropriate, and/or insignificant to the stated need or problem.
Possible Solutions	• At least three ideas are considered and explained in detail. • Detailed sketches are created for the selected ideas. • Sketches are labeled with dimensions and materials for each component.	• At least two ideas are considered and explained in detail. • Detailed sketches are created for the selected ideas. • Sketches are labeled with dimensions and materials for each component.	• At least two ideas are considered and explained. • Sketches created for selected idea(s) are missing details, labeled dimensions, and/or materials for each component. •	• Only one idea is considered and explained. • Sketches created for selected idea(s) are poorly drawn, missing labeled dimensions, and materials for each component.
Solution	• Chooses one design to implement and clearly explains how it will solve the problem using supporting evidence. • A scaled blueprint articulated in 2D and 3D is created for the selected design with precision in all measurements. • All dimensions are clearly labeled.	• Chooses one design to implement and clearly explains how it will solve the problem. • A scaled blueprint articulated in 2D is created for the selected design with precision in most measurements.	• Chooses one design to implement and partially explains how it will solve the problem. • A scaled blueprint articulated in 2D is created for the selected design with precision in some measurements.	• Chooses one design to implement and description is unclear and/or doesn't explain how their design solves the problem. • A blueprint articulated in 2D is created for the selected design with minimal precision.
Prototype	• An all-inclusive and descriptive (quantity, size, material, etc.) list of materials is included.	• An all-inclusive list of materials is included. • Procedures are included, logical, and	• A list of materials is included with some items missing. • Procedures are	• A list of materials was mostly incomplete or missing altogether. • Procedures are illogical

	• Procedures are included, detailed, easy to follow, logical, and complete. • Prototype is well constructed, accurately fabricated to specifications, fully functional and suitable for design verification.	complete. • Prototype has implementation and/or fabrication deficiencies but is of high quality to verify design.	included, logical, and incomplete. • Prototype has implementation and fabrication deficiencies but is of sufficient quality to verify design.	and incomplete, or missing. • Prototype is poorly constructed and is not suitable for design verification.
Test & Evaluate	• Strengths and weaknesses of the design are documented in an organized manner. • Results are accurately recorded in a data table that is complete and well organized. • Includes a clear and concise synopsis of how the chosen design effectively addresses the identified problem.	• Strengths and weaknesses of the design are documented. • Results are accurately recorded and complete. • Includes an effective synopsis of how the chosen design effectively addresses the identified problem.	• Strengths or weaknesses of the design are documented. • Results are recorded but are somewhat inaccurate. • Includes a somewhat clear synopsis of how the design effectively addresses the identified problem.	• Strengths and/or weaknesses of the design are inappropriate or not documented. • Results are inaccurate or not recorded. • Includes an unclear or inappropriate synopsis of how the design effectively addresses the identified problem.
Redesign or Improve the Solution	• Modifications to improve the design are entirely based on test results. • Modifications to the design are documented in a well-organized manner. • At least two additional	• Modifications to improve the design are mostly based on test results. • Modifications to the design are documented. • At least one additional trial is conducted and recorded.	• Modifications to improve the design are somewhat based on test results. • Modifications to the design are partially documented. • At least one additional trial is conducted and	• Modifications to improve the design are inappropriate or not performed. • Modifications to the design are not documented. • No additional trials were conducted or

	trials are conducted and recorded in a well-organized manner. • Reflections show great insight and understanding of process and goals of project.	• Reflections show understanding of process and goals of project.	recorded. • Reflections show partial understanding of process and goals of project.	recorded. • Reflections show minimal understanding of process and goals of project.
Communicate the Solution (Presentation, Societal impact, Display)	• Presentation is well organized, visually appealing, and engages the viewers. • Presentation covers all areas of the design process. • Presentation is clearly communicated (verbally and visually) with appropriate data, sketches, graphs, pictures, and labels. • Presentation includes equal contributions from all team members.	• Presentation is well organized. • Presentation covers most areas of the design process. • Presentation is clearly communicated (verbally and visually) with appropriate data, sketches, graphs, and pictures. • Presentation includes contributions from all team members.	• Presentation is somewhat organized. • Presentation covers some areas of the design process. • Presentation is partially communicated (verbally and visually) with appropriate data, sketches, graphs, and pictures. • Presentation includes contributions from some team members.	• Presentation is unorganized. • Presentation covers few areas of the design process. • Presentation is minimally communicated (verbally and visually) with appropriate data, sketches, graphs, and pictures. • Presentation includes contributions from only a few team members.

Design Challenge: Total Number of Points / 9

3.5 – 4.0	Advanced
3.0 – 3.49	Proficient
2.0 – 2.99	Partially Proficient
0 – 1.99	Unsatisfactory

Eliciting Invention & Innovation Ideas

Journal Entry:	Tips:	Examples:

Life's Frustrations	▪ What annoys you in everyday life? ▪ Observe other students at school to see what products they use and get frustrated with? ▪ Interview friends and family about everyday problems they're having.	▪ Orange fingers after eating Cheetos. ▪ I always lose my pencil.

Journal Entry:	Tips:	Examples:
World Problems	▪ Interview adults. ▪ Interview the elderly or people with disabilities to learn about the difficulties they face each day. ▪ Consider adaptive devices to help individuals and animals with a wide range of physical challenges. ▪ Have a discussion with someone that is less fortunate than you. ▪ Conduct research using the internet or the library.	▪ Need to recycle. ▪ Helping the homeless. ▪ Need for prosthetics.

Journal Entry:	Tips:	Examples:
Dream Inventions	▪ If you could invent anything at all – what would you invent? ▪ List crazy and fun ideas. ▪ Ignore practicality. ▪ Write down any invention ideas you may have had as a child.	▪ Hot chocolate tea bags. ▪ Time machine.

Eliciting Invention & Innovation Ideas Cont…

Journal Entry:	Tips:	Examples:
Existing Inventions	▪ Improve upon an invention that you know and like. ▪ Aim an existing invention for a different audience? ▪ Determine who uses a specific object and then figure out whom else might benefit from its characteristics. ▪ What can be added or improved to existing inventions to better meet the needs of a new audience?	▪ My slippers aren't warm enough in winter.

Journal Entry:	Tips:	Examples:
Combined Inventions	▪ Take two existing products and put them together to create a new product with the combined characteristics of the two original ones. ▪ Think which two products are complimentary to each other, and can benefit from being combined into one product.	▪ Fork with a hollow cavity to dispense sauces such as ketchup or ranch onto food.

Journal Entry:	Tips:	Examples:
Deconstructed Inventions	▪ Take away one or more parts of an existing product and make a new use for it.	▪ Remove the wheels from a bicycle to make a stationary exercise bike.

Engineering Notebook/Journal Format

1. **Title Page (1st page)**
   The title page should consist of the project title, student name, school, and date.
2. **Table of Contents (1 - 2 pages)**
   Students will make a table of contents that shows where the pages of the Engineering Design process steps are found with page numbers so these steps can be easily located. Since the notebook/journal is a living document the page numbers will be added to the table of contents as they progress through the project.

- Define a need
- Research
- Design Requirements
- Project Prototype Designs
  - Beginning Prototype Designs
  - Final Prototype Designs
  - List of Materials
  - Step-by-step procedure
- Building, Testing and Recording, and Analyzing the Prototype.
- Redesigning, Retesting and Recording, and Analyzing the Prototype.
- Conclusion

3. **<u>The Engineering Design</u>**

   In this section the students will write and date what they did or discovered by following each part of the Engineering Design process.

   - Define a need page
     - Journal of ideas
     - Problem statement
   - Research and Investigation page(s)
   - Design Requirement page
     - Criteria and Constraints
   - Project Designs
     - Beginning Designs page
     - Final Designs page
     - List of Materials page
     - Step-by-step procedure page
   - Building, Testing and Recording, and Analyzing the Prototype.
     - Building the Prototype page
     - Testing and Recording page
     - Analysis page
   - Redesigning, Retesting and Recording, Analyzing the Prototype.
     - Redesigning page
     - Retesting and Recording page
     - Analysis page
   - Conclusion page

4. **<u>Bibliography</u>**

   Students write a list of three or more sources that they used for research by telling the type of source, title, and page numbers.