Lesson 8: Exploring a Design Process (The Steps)
(Adapted from the Exploration Design Challenge, NASA)

The engineering design process is a series of steps that guides engineers and engineering teams as they solve problems. The design process is iterative, meaning that they repeat the steps as many times as needed, making improvements along the way as they learn from failure and uncover new design possibilities to arrive at great solutions.

Learning Goals: Students will

- learn the steps of the engineering design process
- evaluate each step through an example
  (Note: use the problem generated in lesson 7)

Materials:

- the design process hand-out
- worksheet
- pen

Activity Instructions: (Answer what is being asked in each step in separate sheets of paper – i.e. design sheets).

Step 1: Identify the problem.

- State the problem clearly.

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Step 2. Identify Criteria and Constraints.

- Identify the conditions that must be met to solve the problem.
- Identify anything that might limit a solution, such as cost, availability of materials, safety.
- Be specific.

Step 3. Brainstorm Possible Solutions

- Consider what others have done to solve this problem and include prior research. Do background research.
- Generate new ideas for solutions. Brainstorm.

Step. 4. Select A Design.

- Choose two or three of the best ideas from the 'brainstormed' list.
- Make a detailed sketch of each design proposed.
- Label each sketch (complete with dimensions) and include a list of all the materials needed to build a model.
- Select the best design to construct.
- Justify your choice by listing the reasons why you chose the design.

Step 5. Build a Model or Prototype

- Write a detailed procedure for building the model or prototype.
- List the materials actually used to construct the model or prototype.
- Follow the procedure and build the model or prototype.

Step 6. Test the model or prototype

- Write a hypothesis about your design's performance prior to testing.
- Use an "If…then…" format.
- Decide on a test to use for the model or prototype and try it out.
- Record the results of your tests.

Step 7. Evaluate results.

- List the strengths of your design.
- List the weaknesses of your design.
- Discuss what changes, or compromises, in your design (if any) had to be made due to constraints.
- Decide if your design solved the problem identified in Step 1.

Step 8. Refine the Design.

- Based on the results of your tests, make improvements on your design.
- Identify the changes that you will make.
- Give the reasons for the changes (based on the results of the tests).

Step 9. Share the design.

- Organize your findings. (e.g. poster, digital collage, PowerPoint presentation, short video documentary etc.)
- Present your findings for feedback.
- Compare your design with others.
- If you are to build this model or prototype again, what would you do differently and why?

The Engineering Design Process:

1. Define a need – (i.e. your expressed as a goal)

2. Establish your design criteria and constraints

3. Evaluate alternative designs

4. Build a prototype of your best design

5. Test and evaluate the prototype using the design criteria

6. Analyze your test results, make design changes (if needed), and retest

7. Communicate the design

Step 1. Identify a need

The need (also called the problem you are solving or your engineering goal) is frequently identified by customers (i.e. the users of the product). The customer could be a retail consumer or the next team in a product development. Customers may express their needs by describing a product (e.g. "I need a car.") or as a functional requirement (e.g. "I need a way to get to school.") The need should be described in a simple statement that includes what you are designing (i.e. the product), who it is for (i.e. the customer), what need does it satisfy (i.e. the problem to solve), and how does it improve previous designs (i.e. is it easier to use, less expensive, more efficient, or safer).

Step 2. Establish the design criteria and constraints

Design criteria are requirements you specify that will be used to make decisions about how to build and evaluate the product. Criteria are derived from needs expressed by your customers. Criteria define the product's physical and functional characteristics and must be declared as a measurable quantity. Some examples of measurable criteria include length; mass; velocity; and ruggedness (i.e. able to withstand an impact force). Some examples of measurable accuracy include, '…fewer than y errors per m/s…' or '…fewer than z particles per liter of fluid….' Constraints are factors that limit the engineer's flexibility. Some typical constraints are cost, time, and knowledge; legal issues; natural factors such as topography, climate, raw materials; and where the product will be used. Good designs will meet important design criteria within the limits fixed by the constraints. Good designs are also economical to make and use because cost is always a design constraint!

Step 3. Evaluate alternative designs and create your test plan

Your research into possible solutions will reveal what has been done to satisfy similar needs. You will discover where knowledge and science limit your solutions, how previous solutions may be improved, and what different approaches may meet design objectives. You should consider at least two or three alternative designs and consider using available technology, modifying current designs, or inventing new solutions. Superior work will demonstrate tradeoff analyses such as comparing the strength vs. cost of various bridge-building materials.