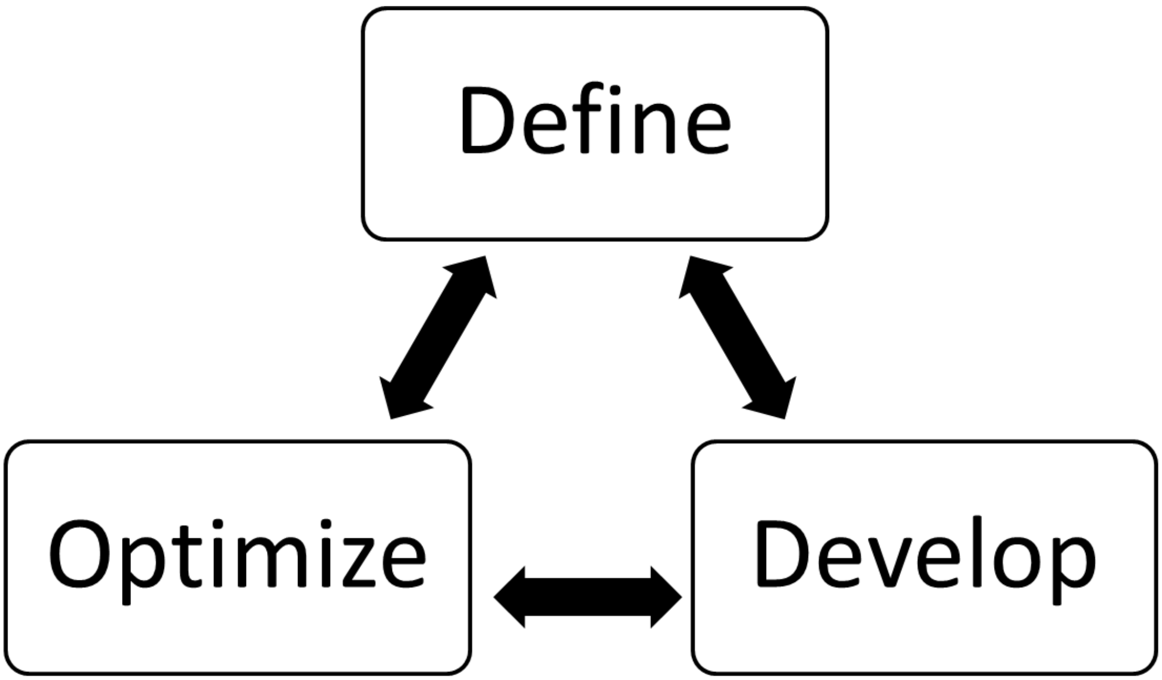
Arts & Bots

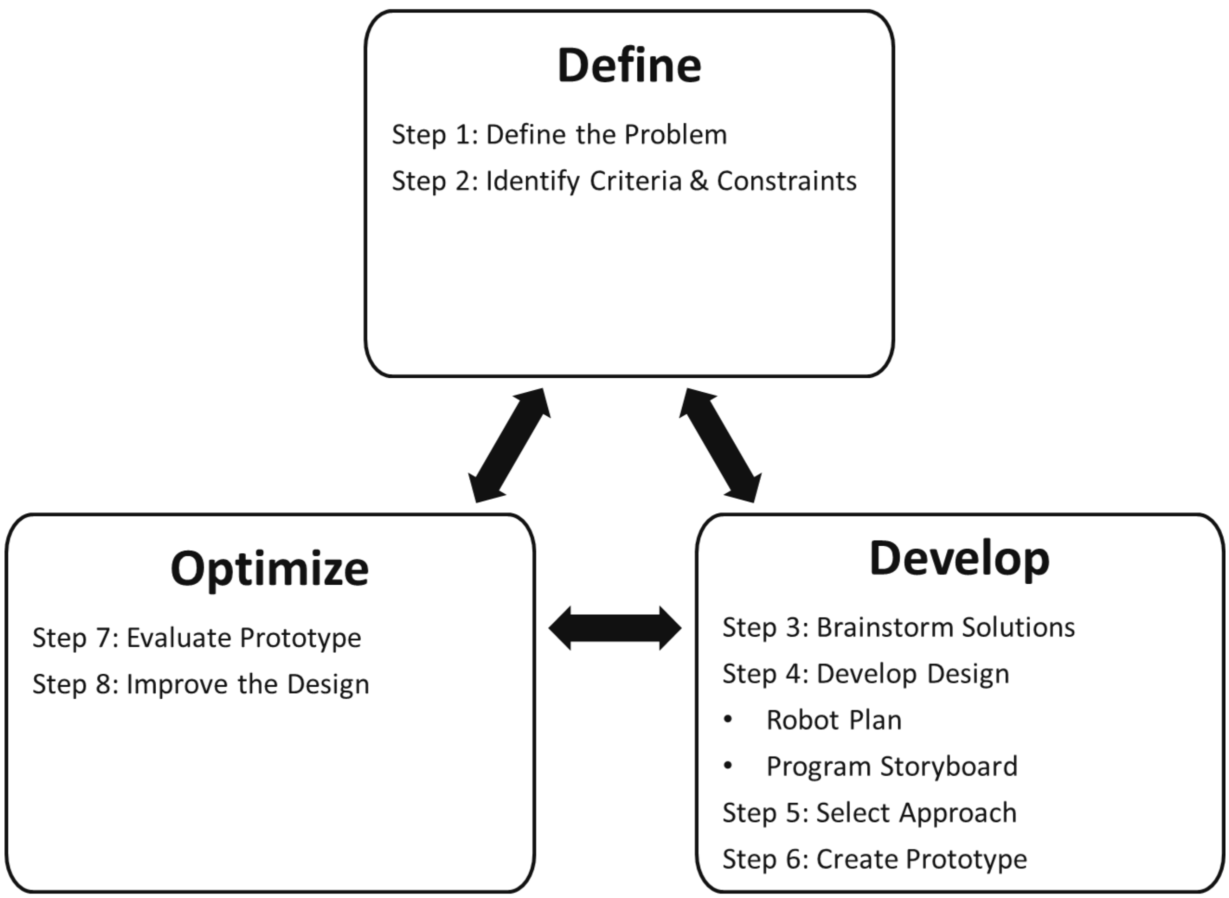
Design Notebook



THIS NOTEBOOK BELONGS TO:

DATE:

Engineering Design Process Steps



Date: ______________________________

Define

STEP 1: DEFINE THE PROBLEM OR GOAL

What do you want your robot to look like?

What do you want your robot to be able to do?

Do you have any other goals for your robot?

Date: ______________________________

Define

STEP 2: IDENTIFY CRITERIA AND CONSTRAINTS

What are your criteria for success? How will you decide if the robot meets your goals?

What constraints limit your design?

Assignment Requirements:

Materials:

Time:

Other:

Date: ________________________________

Develop

STEP 3: BRAINSTORM SOLUTIONS

Brainstorm, sketch and/or list your ideas for making a robot to meet these goals:

Date: ______________________________

Develop

STEP 3: BRAINSTORM SOLUTIONS

Brainstorm, sketch and/or list your ideas for making a robot to meet these goals:

Date: ________________________________

Develop

Design Number

____

STEP 4: DEVELOP DESIGN—ROBOT PLAN

What will your robot look like? What materials will you need?

Date: ______________________________

Develop

Design Number

______

STEP 4: DEVELOP DESIGN—PROGRAM STORYBOARD

Expression #______

Expression #______

Expression #______

Expression #______

Expression #______

Expression #______

Date: ______________________________

Develop

STEP 5: SELECT APPROACH

Which design will meet your goals best? Does it match your constraints?

What are the pros and cons of the designs?

Select which design to create: Design Number __________

Date: ______________________________

Develop

STEP 6: CREATE A PROTOTYPE

Build your robot prototype. You may need to test parts and revise your designs as you build.

How is the robot different from your design plan?	Why did you make that change?

What materials and parts did you use ?

Date: ______________________________

Optimize

STEP 7: EVALUATE THE PROTOTYPE

How well does your robot meet your goals and criteria ?

What works? Which goals did you meet?	What does not work? Which goals were not met?

Date: ______________________________

Optimize

STEP 8: IMPROVE THE DESIGN

What could work better? How could you meet your remaining goals?

Connecting to the Next Generation Science Standards

Define	Develop	Optimize
ETS1.A	**ETS1.B**	**ETS1.C**

Middle School Engineering Design from Next Generation Science Standards

Students who demonstrate understanding can:

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-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

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.

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

SCIENCE AND ENGINEERING PRACTICES

Asking Questions and Defining Problems
Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

DISCIPLINARY CORE IDEAS

ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

CROSSCUTTING CONCEPTS

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

This table was reproduced from the Next Generation Science Standard on February 2014.

Disciplinary Core Ideas and Grade 8 Endpoints

DEFINE

What is a design for?
What are the criteria and constraints of a successful solution?

By the end of grade 8: The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (e.g., familiarity with the local climate may rule out certain plants for the school garden).

DEVELOP

What is the process for developing potential design solutions?

By the end of grade 8: A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others.

Models of all kinds are important for testing solutions, and computers are a valuable tool for simulating systems. Simulations are useful for predicting what would happen if various parameters of the model were changed, as well as for making improvements to the model based on peer and leader (e.g., teacher) feedback.

OPTIMIZE

How can the various proposed design solutions be compared and improved?

By the end of grade 8: There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Comparing different designs could involve running them through the same kinds of tests and systematically recording the results to determine which design performs best. Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful.

Prompt questions and grade band endpoints reproduced verbatim from:

National Research Council (NRC) 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.