# Next Generation Science Standards and Let’s Start Coding Kits

Grades 6-8

# Introduction

The Next Generation Science Standards for Engineering Design focus on the ability of students to navigate the process of solving a problem through iteration. We focus our efforts here on the process of creating a model solution to a real-world design challenge with the Let's Start Coding kit.

To create a design challenge that students can work to solve over the course of several meetings, it is important to have a "customer" who can answer subjective questions about criteria for a solution. We suggest that you, the educator, act as the "customer" throughout the design process, evaluating solutions that students propose or create.

Creating a design challenge for your class will work best with groups of 2-5 students. It's important to have differing opinions and approaches, but not so many potential solutions that you cannot evaluate them. As students iterate through the design process, you may want to merge groups that are working on very similar ideas.

Documentation of the process is critical to evaluating success. At each step of the process, try to document the criteria for a solution, the constraints students face, the types of tests students run and the results of those tests, and the reasoning behind design decisions.

Do you have feedback, questions, or comments for our team? Email us at info@letsstartcoding.com !

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# Example of a Design Challenge

In order to adequately address all of the standards in the NGSS Engineering Design, you should allow for multiple (4-8) class meetings to complete your design challenge with Let's Start Coding kits. Some examples of design challenges may be:

"Our school needs to cut back on its electricity usage by reducing number of lights on in classrooms where noone is present. If students or teachers forget to turn off the lights, it costs the school money and wastes energy. How could we use our Let's Start Coding kits to design a model solution to this problem?".

**Ideation**
Potential model solutions to this problem are to put the lights on a timer that automatically goes off. However, that may mean that lights go off when class is in session.

Students may iterate on the idea and come up with a notification alarm that beeps 3 minutes before the lights turn off. That gives the teacher a chance to press a 'stay on' button to keep the lights on. They may decide to flicker the lights on and off quickly, saving some electricity by making the lights slightly dimmer all of the time.

As students begin to come up with ideas, the teacher should play the role of the customer, sharing more and more about their constraints, concerns, and satisfactory solutions. Students can document these and prioritize them with the customer, or a master list can be created and publicly posted for each student to work from. During this time, ask students to keep in mind the implications this customer, but also to think about the solution in terms of the broader school, district, or city.

**Grouping**
Once the problem has been discussed as a singular group, it may be appropriate to separate students into working groups. Because they may only need to use one Maker Board and Let's Start Coding kit, you may assign roles to students to follow throughout the process. Roles may include:

- **Customer diplomat**: Someone nominated to speak directly with the customer to understand their needs, then bring the learning back to the group and help them integrate the questions into the solution.

- **Documentarian**: Someone in the group to help keep track of changes made to the design and critical decision points or points of contention throughout the process. This person should be keeping track of progress and be able to use their notes to answer the question: "Why did you take this approach?"

- **Coder**: This group member or members will be in charge of interpreting the customer's needs into actual code on the computer. They will work with the customer diplomat to understand what needs to be done and how. It may be useful to have multiple students in this role to help research and troubleshoot.

- **Tester**: This student helps design the right criteria to test the solution by and carries out those tests to help the group decide if they are succeeding or not. In the example of the automatic light switch, the tester may find a way to test how loud or annoying the alarm should be for the teacher to hear it. They may test how reliably their code works to help find unseen problems.

**Modeling**
Students will obviously not create a system to control the lights in their classroom or school. Instead, they will likely use the small speaker and LEDs from their Let's Start Coding kits to *model* the larger solution. It is not difficult for students to imagine the LED bulbs instead being the bulbs overhead.

**Evaluation**
Evaluation of the groups' ideas can be class-wide and facilitated by you, the customer, as you consider each solution and how well it fits your constraints and solves the problem. Evaluation will be a recurring activity as groups iterate and take feedback from these sessions to continue to code and build a solution.

During these evaluation sessions, establish qualitative and quantitative criteria for a successful solution. These will help your students develop tests that can produce data.

**Testing**
Testing of a solution can occur on an individual group level or with the help of the customer. Students should be able to use the constraints and criteria to design and carry out tests for the technical success of the project as well as meeting the criteria set by the customer.

Data involved in these tests will vary depending on the design challenge. In our example above, tests may include the reliability of lights turning off as well as different intervals for the lights to turn off and the notification system for the design.

**Final Design**
Groups may consolidate as their design ideas converge to a nearly-identical path. Near the end of the design challenge, the class and the customer should evaluate their designs and find the optimal solution(s). You may wish to have each group create a presentation, drawing from each of the group members' data: the documentation, the code itself, the tests that were run and the customer interaction that led to the final design the group created.

# NGSS Middle School Engineering Design: Science and Engineering Practices

## MS-ETS1-4

### The Standard

**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.

This standard applies to the Lessons and the Design Challenge.

### What's the Connection?

Programs and projects can be models of real-world devices, technology, and phenomena including randomness, human interaction with technology, small scale design of larger imagined systems.

# NGSS Middle School Engineering Design: Disciplinary Core Ideas

## MS-ETS1.A

### The Standard

**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.

### What's the Connection?

By working with a limited set of electronics hardware, students will face constraints about what is possible. For example, the brightest possible set of lights a student can create is limited by the number of LED lights available to them.

Students will reconcile the fact that they may imagine a perfect solution, but are limited to only some resources to find a feasible but still satisfactory outcome.

# MS-ETS1.B

## The Standard

**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)

## What's the Connection?

Coding is an iterative process of creating better and better prototypes. The tests are nearly immediate and they can be evaluated in concrete terms. If students are working individually or in groups, they can compare their outcomes with nearby groups and learn which methods are the most successful.

# MS-ETS1.C

## The Standard

**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)

## What's the Connection?

By working in small groups, students can compare code, designs, and outcomes to find the best functionality for the final design.

# NGSS MS-ETS1 Engineering Design: Standards

## MS-ETS1-1

### The Standard

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.

### What's the Connection?

One of the most important coding abilities is articulating precisely what the computer program or project should accomplish. Students can work with a "customer" (the educator or a group of students who are communicating an imagined need) to clarify in human terms what design problem they are facing and what a satisfactory solution will look like.

Students will then translate these human terms into computer coding. They may need to revisit their "customer" on multiple occasions to refine and revise their understanding of the problem.

As students iterate through prototypes of the solution and consider their approach, they will become aware of constraints based on the available electronics, their own coding skills, and the other materials available in the classroom.

# MS-ETS1-2

## The Standard

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

## What's the Connection?

Computer programming allows a number of different and correct paths to be taken toward any solution. Paths can be optimized for different factors, such as speed, simplicity, ease of maintenance, or flexibility.

Students working in groups on a design project will arrive at different conclusions to solve a problem. Sometimes, the conclusions may not even be visibly different in their output, but significantly different in their coding approach, style, and effectiveness.

Beyond the criteria of the imagined or real "customer" in a design challenge, students must think critically about their own technical creations and assess the best approach to meet that customer criteria.

# MS-ETS1-3

## The Standard

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.

## What's the Connection?

If multiple groups of students are building parallel coding solutions to an imagined customer problem, they can run both quantitative and qualitative tests on their respective solutions and decide as a group which characteristics are most important for the final product.

For example, students may find with experimentation and testing that some solutions are very clever but not reliable. Other solutions may provide only some of the features that the "customer" asked for but do so in a very reliable manner. Which characteristic is more important? Students will answer that question using the data from their tests.

# MS-ETS1-4

## The Standard

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.

## What's the Connection?

As students determine the most important criteria for their design solution, they will iterate on their code projects to improve the quality of the solution. Students can create a model for sharing code (i.e. 10 minute demos at the end of class or a bulletin board with every program printed out) that keeps each group aware of each others' iterations.

Depending on the design project that students are working on, they may identify key metrics of success and design tests to show which design is best passing those tests.