Defining Functions

(Also available for WeScheme)

Students discover functions as an abstraction over a programming pattern, and are introduced to a structured approach to building them called the Design Recipe.

Prerequisites	Defining Values
Relevant Standards CC-Math	*Select one or more standards from the menu on the left (⌘-click on Mac, Ctrl-click elsewhere).*
Lesson Goals	Students will be able to: • Describe the usefulness of ***functions***. • Create their own functions and ***examples*** given the constraints of a problem.
Student-Facing Lesson Goals	• I can explain why a function is useful. • I can plan and create my own function with examples.
Materials	• Lesson slides template (Google Slides) • Mapping Examples with Circles of Evaluation worksheet (HTML (Page 25)) • Fast Functions worksheet (original (Page 26), solutions)
Preparation	• Make sure all materials have been gathered • Decide how students will be grouped in pairs
Supplemental Resources	• Expression Bundle (Desmos Activities) • Variables and Expressions (Quizizz) • Functions Bundle (Desmos Activities) • Function Notation (Quizizz)
Key Points for the Facilitator	• This lesson represents a big shift in thinking. After some practice, students will not be limited to pre-existing functions! • Take plenty of time for the ***Design Recipe*** as students will return to it frequently in future lessons.

For a textbook-like version of materials similar to these, you may wish to see the prior unit-based version

Glossary

contract :: a statement of the name, domain, and range of a function

definitions area :: the left-most text box in the Editor where definitions for values and functions are written

design recipe :: a sequence of steps that helps people document, test, and write functions

example :: shows the use of a function on specific inputs and the computation the function should perform on those inputs

function :: a mathematical object that consumes inputs and produces an output

Number :: a data type representing a real number

syntax :: the set of rules that defines a language, whether it be spoken, written, or programmed.

Warmup

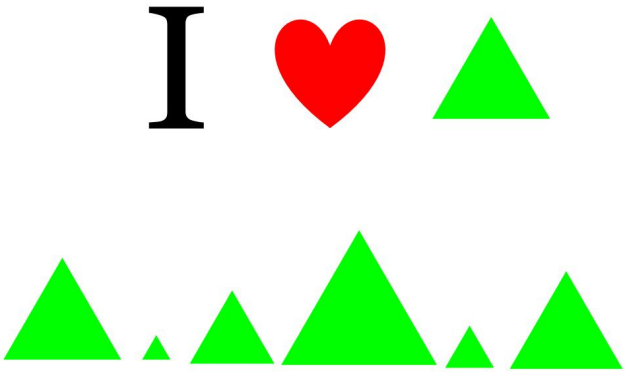
Students should have their workbook, pencil, and be logged into code.pyret.org on their computer.

Identifying Repeated *Patterns* 30 minutes

Overview

As with the Defining Values lesson, students search for structure in a list of expressions. But this time, the structures are *dynamic* , meaning they change in a predictable way. This is the foundation for defining functions.

Launch



Confess to your students, "I LOVE green triangles." Challenge them to use the ***Definitions area*** to make as many DIFFERENT solid green triangles as they can in 2 minutes.

Walk around the room and give positive feedback on the green triangles. After the 2 minutes, ask for some examples of green triangles that they wrote and copy them to the board. Be specific and attend to precision with the ***syntax*** such that students can visually spot the pattern between the different lines of code.

For example:

```
triangle(30,  "solid", "green")
triangle(12,  "solid", "green")
triangle(500, "solid", "green")
```

Notice and Wonder

Direct students to the various lines of code they came up with. What do you notice? What do you wonder?

- **Is there a pattern?** *Yes, the code mostly stayed the same with one change each time.*
- **What stayed the same?** *The function name* `triangle` *, "solid", "green".*
- **What changed?** *The number being given to* `triangle` *, or the* ***Number*** *input.*
- **What strategy did you use to create many different triangles?** *Answers vary: Pattern matching, copy and paste*
- **What shortcut did we use before when we wanted to use the same code over and over?**
  We defined values in the Definitions area.

We've learned how to define **values** when we want to create a shortcut to reuse the same code over and over.

For example:

```
myStar = star(50, "solid", "gold")
```

But to make a shortcut that *changes* such as creating solid, green triangles of a changing size, we need to define a *function*.

Suppose we want to define a shortcut called `gt`. When we give it a number, it makes a solid green triangle of whatever size we gave it.

Select a student to *act out* `gt`. Make it clear to the class that their Name is "gt", they expect a Number, and they will produce an Image. Run through some sample examples before having the class add their own:

- You say: **gt 20!** The student responds: *triangle(20, "solid", "green")!*
- You say: **gt 200!** The student responds: *triangle(200, "solid", "green")!*
- You say: **gt 99!** The student responds: *triangle(99, "solid", "green")!*

We need to program the computer to be as smart as our volunteer. But how do we do that?

Investigate

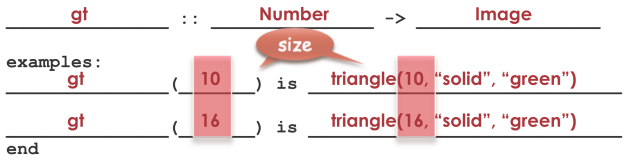
Word Problem: Write a function called `gt` that takes in a Number and produces a solid, green triangle of that given size.

Have students follow along on the Fast Functions (Page 26) handout.

- **1. Write the *contract* for this new function by looking at the word problem.**
  - What does `gt` take in?
    A Number
  - What does `gt` give back?
    An Image. Students may say "a triangle", follow up by asking what data type that triangle will be (Number, String, or Image)
- **2. Write some examples of how this function should work.**
  - If I typed `gt(40)`, what would I want the program to do?
    I'd want the computer the execute the code `triangle(40, "solid", "green")`.

This is a tough question at first. If students are unsure, remind them that we're just writing a shortcut for making green triangles so we don't have to type `triangle`, *"solid", and "green" every time!*

- OPTIONAL: Have students complete the Mapping Examples with Circles of Evaluation (Page 25) worksheet showing how their function examples are working.
- **3. Circle and Label what is "change-able" - or *variable* between the examples. Circle and label it with a name that describes it.**
  The number is changing in each example. We could name it "x", but "size" is a more accurate name.



- **4. Write the function definition.**

Look at the two examples. The function definition will follow the same pattern, but it will use the variable name `size` *in place of the variable part we circled. We also use the keyword* `fun`, *replace the colon (* `is` *) with a colon (* `:` *), and finish it off with an* `end`.

```
fun gt(size): triangle(size, "solid", "green") end
```

Connecting to Best Practices

- Writing the examples is like "showing your work" in math class.
- Have students circle what is changing and label it with a proper variable name. The name of the variable should reflect what it represents, such as `size`.

> - Writing examples and identifying the variables lays the groundwork for writing the function, which is especially important as the functions get more complex. Don't skip this step!

Now that students have defined `gt` have them save their program as 'Defining Functions' and test out their newly created function in the Interactions window.

Synthesize

- **What is the domain for `gt` ?** *Number*
- **Why might someone think the domain for `gt` contains a Number and two Strings, because that's the Domain of `triangle` ?** The function `gt` *uses* `triangle` , but only needs one Number input because *that's the only part that's changing.*
- **Why is defining functions useful to us as programmers?**

Practicing the Design Recipe

flexible

Overview

This is a chance for students to independently review the steps learned in the prior activity, with the teacher in a supporting role asking guiding questions and giving support when needed.

Launch

Word Problem: Write a function called `gold-star` that takes in number and produces a solid, gold star of that given size.

- Write 2 examples and the definition of `gold-star` on the 'Fast Functions' handout.
- Complete the `gold-star` example on the Fast Functions (Page 26) worksheet.

Investigate

- Design a problem for a function that takes in one input and returns a shape that uses that input. Your function's input could be a Number, as in the two examples, or a String.
- Write two examples and a definition for your function
- Complete the Mapping Examples with Circles of Evaluation (Page 25) for the examples of your function.

Closing

The Design Recipe is a powerful tool for solving word problems. In this lesson, students practiced using it on simple *programming problems* , but soon they'll be applying it to traditional math problems. Encourage them to make this connection on their own: can they think of a math problem in which this would be useful?

Additional Exercises:

- Matching Examples & Function Definitions (original , answers)
- Creating Contracts from Examples (1) (original , answers)
- Creating Contracts from Examples (2) (original , answers)