Functions Make Life Easier!

(Also available in WeScheme)

Students discover that they can make their own functions.

Lesson Goals	Students will be able to: • identify patterns where a function would be useful • define their own function
Student-Facing Lesson Goals	• Let's learn how functions get defined! • Let's use patterns to write some functions.
Prerequisites	• Simple Data Types • Contracts
Materials	• PDF of all Handouts and Page • gt Starter File • Lesson Slides • Printable Lesson Plan (a PDF of this web page)
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!

Glossary

define :: to associate a descriptive name with a value
domain :: the type or set of inputs a function expects, i.e., the independent variable(s) that govern the output of the function
function :: a relation from a set of inputs to a set of possible outputs, where each input is related to exactly one output
value :: a specific piece of data, like 5 or "hello"
variable :: a name or symbol that stands for some value or expression, often a value or expression that changes

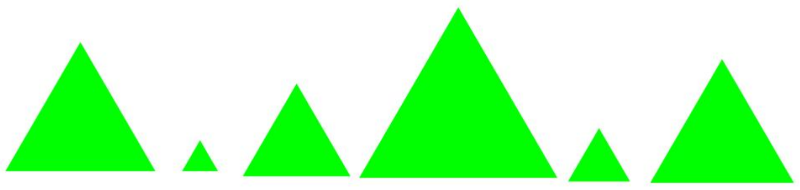
There’s Got to Be a Better Way! *15 minutes*

Overview

In this lesson, students will build their flexibility of thinking by engaging with multiple representations. Students will search for structures that are *dynamic*, meaning they change in a predictable way. This is the foundation for defining functions.

Launch

This is a fun lesson to make silly! Dramatically confess to your students, "I LOVE green triangles!" Challenge them to use the Definitions Area to code as many unique, solid, green triangles as they can in 2 minutes.



Walk around the room and give positive feedback on the green triangles. When the time is up, ask for some examples of green triangles that they wrote and copy them to the board.

For example:

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

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

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

Invite students to analyze the examples you recorded by posing the following questions:

- 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 size of the* `triangle`*, or the Number input.*
- How many of you typed out the code from scratch each time?
- How many triangles were you able to code in a minute?
  - *Write this down so that you can compare to it later!*

Investigate

Our programming language allows us to define ***values***. This lets us create "shortcuts" to reuse the same code over and over.

For example: `gt = triangle(65, "solid", "green")` allows us to make the same solid, green triangle anywhere we want, just by writing `gt` - without having to write all of the code again and again. But… it makes the same green triangle *every* time.

> 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 function called `gt`. When we give it a number, it makes a solid green triangle of whatever size we give it. What will `gt(5)` produce? `triangle(5, "solid", "green")`*!*

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.

Just as with any acting career, this one will begin with a rehearsal. When I say, "**gt 5!**", you say, "**triangle 5 solid green!**" Let's try it.

- Teacher: **gt 5!**
- Student: `triangle(5, "solid", "green")`*!* **Note: Have the actor ignore the punctuation, and just say "triangle 5 solid green!"**
- Teacher: **gt 20!**
- Student: `triangle(20, "solid", "green")`*!*
- Teacher: **gt 200!**
- Student: `triangle(200, "solid", "green")`*!*
- Teacher: **gt 99!**
- Student: `triangle(99, "solid", "green")`*!*

That was a great rehearsal. You're ready for the stage! Now it's the class' turn to give you cues! Who's got a `gt` expression for our actor?

> Go around the room soliciting `gt` expressions from students until it’s clear that everyone could run this script in their sleep.

Synthesize

Thank your volunteer.

Assuming they did a wonderful job, ask them: How did you get to be so speedy at building green triangles? You seemed so confident! *Ideally they’ll tell you that they had good instructions and that it was easy to follow the pattern.*

Just as we were able to give our volunteer instructions that let them take in `gt 20` and give us back `triangle(20, "solid", "green")`, we can define any ***function*** we’d like in the **Definitions Area**.

Identifying and Describing the Pattern *flexible*

Overview

Students will look for what's changing in the examples, label it with a ***variable*** and use that information to write a function definition. Students will also think about how the ***Domain*** of `gt` differs from the ***Domain*** of `triangle`. By the end of the lesson they will have ***defined*** functions of their own design.

Launch

We need to program the computer to be as smart as our volunteer. But how do we do that? In order to define a function, we need to identify what's changing and what stays the same. Invite students to take a look at the examples for `gt` below:

`gt(5)` ⟶ `triangle(5, "solid", "green")`

`gt(10)` ⟶ `triangle(10, "solid", "green")`

`gt(25)` ⟶ `triangle(25, "solid", "green")`

`gt(100)` ⟶ `triangle(100, "solid", "green")`

`gt(220)` ⟶ `triangle(220, "solid", "green")`

- What's changing?
  - *The size. Everything else is the same in every single example!*

Highlight or circle the numbers in the gt column and in the triangle column to help students see that they're the only thing changing! Explain that we can define our function by replacing the numbers that change with a variable that describes them. In this case, `size` would be a logical variable.

Draw arrows to the two highlighted columns and label them with the word size.

If we keep everything that stayed the same and substitute `size` for the numbers that changed, it looks like this:

`gt(size)` ⟶ `triangle(size, "solid", "green")`

The way we write this in the editor is

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

- Turn to The Great gt domain debate! and "decide and defend" whether Kermit's assertion that *The domain of* `gt` *is* `Number, String, String` or Oscar's assertion that *The domain of* `gt` *is* `Number` is correct.

In the case of `gt`, the domain was a number and that number stood for the `size` of the triangle we wanted to make. Whatever number we gave `gt` for the size of the triangle is the number our volunteer substituted into the `triangle` expression. Everything else stayed the same no matter what!

- Why might someone think the domain for `gt` contains a Number and two Strings?
    - *The function* `gt` *only needs one Number input because that's the only part that's changing. The function* `gt` *makes use of* `triangle`*, whose Domain is Number String String, but* `gt` *already knows what those strings should be.*

Next, direct students to open the gt Starter File, and save a copy of their own. After clicking "Run" and evaluating `gt(10)` in the Interactions Area (they will see a little green triangle appear!), challenge them to take one minute to see how many different green triangles they can make using the `gt` function.

- How many were you able to make?
- How did making green triangles with `gt` compare to making them with your previous strategy?

Investigate

Explain to students that they have successfully defined a function to satisfy your love of green triangles… but other people have other favorite shapes and we need to be able to meet their needs, too. Let's take what we've learned to define some other functions.

- What if we wanted to define a function `rs` to make solid red squares of whatever size we give them? Try it out on Let's Define Some New Functions!.
- Add your new function definitions to your gt Starter File and test them out.
- When you're ready, move on to Let's Define Some More New Functions! and Describe and Define Your Own Functions!

As students work, walk around the room and make sure that they are circling what changes in the examples and labeling it with a ***variable*** name that reflects what it represents.

Connecting to Best Practices

Writing examples and identifying the variables lays the groundwork for writing the function, which is especially important as the functions get more complex. It’s like "showing your work" in math class. Don’t skip this step!

Synthesize

- Why is defining functions useful to us as programmers?
- In math class we mostly see functions that consume numbers and produce numbers, but functions can consume values besides Numbers! What other data types did you see being consumed by these functions?