Function Machine

11

CONTENT AREA

Algebra

Number and Operations

MATERIALS

- optional: overhead projector

TIME

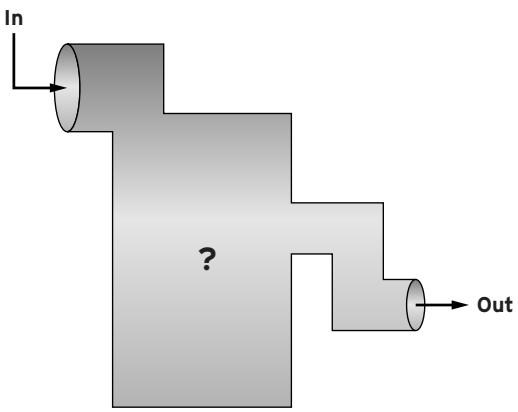
ten minutes

Overview

During the *Function Machine* activity, students look at pairs of numbers and try to generalize relationships and patterns. They also use mathematical language to describe the relationships and to connect the relationships to math vocabulary and symbols. *Function Machine* is a fun and flexible way to encourage communication and algebraic thinking. It also provides a context for introducing and using some of the tools of algebra, such as T-charts.

Activity Directions

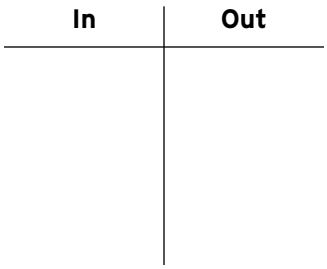
1. Draw a "machine" on the board or an overhead. See the example below.



2. Tell students when a number is put into your machine, the machine follows a certain rule to produce the Out number (e.g., add three). Their job is to figure out the machine's rule.
3. Remind students of the importance of not yelling out the rule the machine is following when they think they've figured it out.

Minilessons for Math Practice, Grades 3–5

4. Draw a T-chart and label the columns *In* and *Out*.



   Explain to the students that the T-chart is a way to keep track of what the machine is doing.
5. Have students tell you a number to put into the machine.
6. Record the number on the T-chart in the In column.
7. Tell students what number would come out. Record that number under the Out column.
8. Continue to add students' suggestions for the In number to the T-chart, record the resulting Out numbers, and have students look for patterns and discuss what the machine might be doing to the numbers.
9. Add a twist by giving the students an Out number and asking them to figure out what number went in.
10. Have students describe what they think the rule is.
11. Record their ideas on the board.

Key Questions

- What do you notice about the numbers on the T-chart?
- What might this function machine be doing?

From the Classroom

Danielle Pickett introduced the *Function Machine* activity to her third graders by drawing an odd-looking tubular machine on the board. The picture piqued their curiosity and she immediately had their attention.

"This," she explained to the class, "is a function machine. A number goes into my function machine, my function machine does something to the In number, and a new number comes out. The function machine always does the same thing to the In number until you guess the rule. Your job is to guess what my machine is doing to the In numbers."

The students seemed excited to get started.

"There are a couple of things you need to know first," Danielle told them. "After you put some numbers into the machine and see what comes out, you'll start to have an idea of what my function machine is doing. It's going to be really important that you don't shout out the answer. We want to make sure everyone in the class has a chance to think as much as possible. OK?"

The students agreed.

"However," she told the class, "if you do think you know what the function machine is doing, you can test out your idea without shouting it out. You can put numbers in and see if you can predict what will come out."

Danielle felt it was important to get these ground rules out in the open at the beginning of the activity. In all classes there is a range of learners and some students are quick to come up with answers or ideas they want to share. When those students always jump in with their thoughts, it has some negative effects on other students. First, the students who need more time to think get discouraged. Second, some students stop thinking altogether because they know someone else will just say the answer for them.

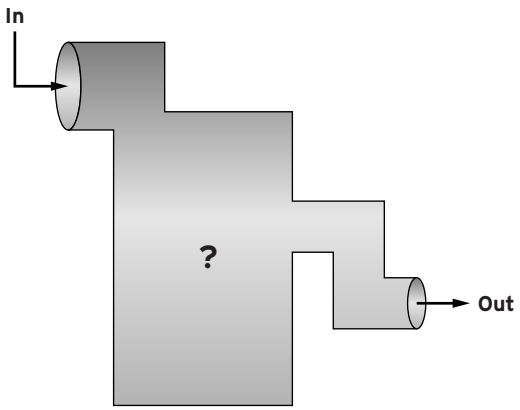
The flip side of this dilemma is that students who do have answers and ideas need to be encouraged. That's why it's important to give them something to do with their ideas other than shout them out. Meeting the needs of a wide range of learners is one of the biggest challenges in teaching whole-class math lessons. Making sure everyone has access to the activity is crucial. For a function machine, a student just needs to be able to suggest a number in order to get involved. This makes the entry point accessible for all students. So two key questions to consider when planning whole-class math lessons are What's the baseline entry point for all students? and What is the challenge or extension for this activity?

Danielle then drew a T-chart on the board, labeling the columns *In* and *Out*. Danielle said to her class, "This chart will help us keep track of the In and Out numbers and help us see what's happening with the numbers. Who would like to give me a number to put into the function machine?"

Many students waved their hands in the air. Danielle called on Carol, knowing that she was an English language learner who was being brave enough to speak in front of the whole class. Even though Carol would be saying only one number, it would help bolster her confidence and encourage her to take more risks in the future.

"Seven?" Carol tried.

"Well," Danielle responded as she wrote on the T-chart, "if a seven goes in, a ten comes out."



In	Out
7	10

"Ooooh!" Amir exclaimed. "I know what it's doing."

"Careful though," Danielle cautioned. "Sometimes you need more information or data before you know exactly what's going on. Also, please don't shout out the machine's rule, as this will stop people's thinking. Does someone want to try a different In number?"

"Put a nine in," Janetta suggested.

"Nine goes in, twelve comes out," the teacher told Janetta while recording the numbers in the chart. "Anyone else?"

"How about three?" John volunteered.

"When a three goes in, a six comes out," Danielle told him.

At this point Danielle could tell many of the students had an idea of what the function machine was doing. She decided to mix things up a bit to keep them involved while giving others more time and more information.

"Nod your head if you think you know what my function machine is doing," she said to the class.

Most students nodded.

"Look at the T-chart," she told the class. "What do you notice about the numbers?"

The students looked a bit confused and hesitant, so Danielle asked a more specific question. "Are the Out numbers greater or less than the In numbers?"

"Greater," the class responded.

"So let's think about this function machine. What operations could it be using that would make a number bigger?"

"Addition," Vincent suggested.

"Or multiplication," Claudia added.

"True," Danielle agreed. "Do the Out numbers get a lot bigger or a little bit bigger?"

"A little," Josue replied.

"So does that tell you anything about the operation the function machine might be using?"

"It's addition, because when you multiply a number it usually gets a lot bigger," Kanani observed.

"Not always," John objected. "Like if you multiply by one or zero, the number stays the same or gets smaller."

"Good point," Danielle acknowledged. "Also, we're using positive whole numbers. Negative numbers or fractions or decimals don't always get bigger when you add or multiply with them."

Danielle was pleased with this brief exchange. She had wanted to bring some of the effects of operations to the surface of the discussion so students would begin to think about them in terms of the *Function Machine*. The discussion also allowed Danielle a chance to refer to negative numbers and fractions, reminding students that it's a big world of numbers out there and they needed to be careful not to overgeneralize. She decided to move on, still using the same rule.

"Now," she told the students, "I'm going to make it a little trickier. This time I'm going to tell you what came out and you need to tell me what went in."

She wrote *8* in the Out column.

"Talk to a neighbor sitting near you. What went in that caused eight to come out? Make sure you really explain your thinking so you understand each other."

Danielle gave the students some time to talk. This talk served two purposes. It allowed students to clarify and verbalize their ideas about the function machine. It also gave students who hadn't yet figured out the function an opportunity to hear others talk about it.

"So what do you think?" she asked the class. "What went into the machine?"

"Five," Kanani said with confidence.

"Rats!" Danielle said, "I thought I could trick you, but you're right. OK, I'm going to try an even harder one. What if I told you twenty-one came out? Talk to a neighbor about what went in."

Danielle deliberately picked a higher number so that the students would do some mental computation. While it's important to introduce the function machine with numbers and operations that are easily accessible, once the students catch on, there are opportunities to have them do some more challenging computation in the context of the machine. She called for the students' attention and asked for a volunteer to give her the In number. She wrote *18* on the T-chart after Terrell shared it.

"All right," Danielle said to the now very confident group, "I can see you're ready for the ultimate challenge. What if I told you that two came out? This is super challenging, so talk to a neighbor and see what you think."

Although these third graders had had minimal exposure to negative numbers, Danielle was curious to see how they might handle this problem. She eavesdropped on the students' conversations. Some students were stuck on zero as the only possibility, but the idea of negative one started to circulate. She called on Sally.

"Negative one," Sally exclaimed.

"Wow," Danielle responded as she wrote -1 on the chart. "How did you figure that out?"

"It's because you have to go back three," Sally explained. "And if you're at two and you go back three, you pass zero and get to negative one."

"Makes sense to me," Danielle agreed. "So let's talk about this function machine. What does it do to numbers? Let's see how many different ways you can find to explain it. Raise your hand if you have a way to describe what the function machine does." She called on Antonio.

"It adds three to the number," he said.

Danielle wrote on the board:

Add three

"Is there another way to describe it?" Danielle asked.

"Plus three," Marta contributed.

Danielle wrote *Plus three* on the board and asked for other ways.

"Take away three," Nikki said.

"Hmm," Danielle responded, "I guess that's true if you look at the Out number first. Let me think of a way to write that." She wrote on the board:

Out number − 3 = In number

"Does that work?" she asked the class.

The students nodded in agreement.

"So can I also write this?" Danielle asked.

In number + 3 = Out number

"Yes," the class replied.

"So there are a lot of ways to describe what this function machine does," Danielle summarized. "I'm impressed with all your thinking today. You've gotten so good at this, maybe you can think of some function machines and I can try to guess them next time." The children were excited by the idea and looked forward to creating their own function machines.

Extending the Activity

Function Machine is very adaptable. Start with a fairly simple function (e.g., +3). Depending on students' levels and area of study, any numbers and operations could be used. Also, you might choose to use a combination of numbers and operations (e.g., $\times 2 + 1$). As students become familiar with function machines, they can start to make up their own rules. Students can then take on the teacher role, leading the activity. It's a good idea to have children prepare their own T-charts for the In numbers from zero to twenty along with the resulting Out numbers. Check the chart prior to having a student share his or her rule. This prevents errors and embarrassment. It also speeds up the process, keeping all students on task. Of course this means that students must suggest numbers from zero to twenty when trying to guess the rule.

Function Machine can also easily be connected to coordinate graphing. The coordinate pairs generated on the T-chart can be plotted on a graph. Students can then discuss what they notice about the graph and how it's related to the function.