

Algorithms, Math and Models

Textbook

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Introduction

Have you ever followed a recipe or a set of directions? That's a real-life version of an **algorithm**—a list of steps that helps you solve a problem or complete a task. In computer science and science class, we use **algorithms**, **math models**, and **simulations** to understand the world. In this lesson, you'll learn how to act out computer logic, solve real problems with math, and use models to study things that are too big, far away, or dangerous to test directly.

Acting Out Algorithms (Computer-Free Programming)

Before you even touch a computer, you can understand how programs work by **acting out the steps**. For example, if you want to write a program to make a sandwich, you can try giving directions to a friend who pretends to be a robot. If your directions aren't clear or in the right order, things might go wrong!

To help plan this kind of logic, computer scientists use something called a **flowchart**. A flowchart is a simple diagram that shows the steps a program takes, like a map for code. Each part of the flowchart has a different shape to show actions, decisions, or outcomes.

Using Math in Real Life

Math isn't just for the classroom—it's a tool that helps you solve problems in the world. If you're planning a school dance, you might use math to calculate how many snacks to buy. If you're building a model bridge, math helps you measure and balance.

Mathematicians often:

- Use **models** to represent real problems
- **Redesign** their methods to be more accurate
- **Check their conclusions** by comparing them to what's really happening

Math is like a superpower that connects to science, engineering, and technology—and it's everywhere in your daily life.

Representing Nature with Models

A **model** is a tool we use to help understand something that's too big, small, far away, or dangerous to test directly. For example, a model of the solar system helps us picture how planets move. A mini version of a bridge helps engineers test its strength.

Models can be:

- **Concrete** (like a 3D volcano)
- **Digital** (like a weather app simulation)
- **Mathematical** (like a graph showing population growth)

Using models helps us explain and predict how natural events happen, from tornadoes to erosion.

What Are the Pros and Cons of Models?

Models are helpful, but they're not perfect. It's important to understand their **benefits** and **limitations**.

Benefits:

- Safer and cheaper than real experiments
- Help test ideas without needing the real thing
- Can speed up long processes (like watching how a coastline changes)

Limitations:

- Might not include every detail
- Can be less accurate than the real thing
- Don't always show what will happen in every location

Let's say you live far from the coast, but you build a model to show how waves erode beaches. That model is useful—but it may not show exactly how things work in a different environment like the Gulf Coast.

Conclusion

Whether you're programming, solving problems, or studying nature, **thinking step-by-step** and **using models and math** helps you make sense of the world. And when you can spot where those models work—and where they don't—you're learning how to think like a scientist and an engineer.

Class Activity

Human Flowchart – Planning a School Field Trip

Overview

Students will **physically act out a flowchart** that models the process of planning a school field trip, making decisions and applying math at each step. They will form a "human program," where each student represents a step or decision. The class will run through the flowchart to simulate how a program (or process) can succeed—or break—based on logic, data, and math inputs.

Materials Needed:

- Index cards or paper labeled with flowchart shapes (Start, Action, Decision, End)
- Tape or string to mark positions on the floor
- Whiteboard or chart paper for designing the flowchart
- Calculators (optional)

Scenario Setup:

Problem to solve: The class wants to plan a field trip with a budget of **\$500**. They must decide where to go, how many students can attend, and what transportation to use. The "program" (students) must calculate costs, check constraints, and make decisions.

Step-by-Step Instructions:

Step 1: Create the Flowchart

Work as a class to design a simple program using flowchart steps like:


1. **Start**
2. **Choose a destination** (zoo = \$15/student, museum = \$12/student, science center = \$18/student)
3. **Calculate total cost** (entry fee × number of students)
4. **Add transportation cost** (\$100 for a bus)
5. **Is total cost ≤ \$500?** (Decision step)
 - If **yes**, → **Confirm trip and move to End**
 - If **no**, → **Choose smaller group or cheaper destination** (loop back)
6. **End**

Assign students to be each **step**, with index cards labeling them as START, DECISION, ACTION, etc. Other students act as "inputs" and move through the flowchart.

Step 2: Run the Simulation

- A volunteer group of 25 students wants to attend the trip.
- Another student acts as "data input," choosing a destination.

- The flowchart steps "process" that data—calculating costs, checking conditions, and looping as needed.
- Students must **perform math calculations** aloud at each step.

 *Example Calculation:* 25 students × \$18 (science center) = \$450 + \$100 (bus) = \$550 → Too much! Try again.

Repeat with different inputs (number of students, destination) to explore other outcomes.

Debrief Discussion

- What happened when your program logic wasn't clear or skipped a step?
- Where did math help you make better decisions?
- Was this model of a real-world situation (field trip planning) helpful? What were its benefits and limits?

Representing Problems in Multiple Ways

When solving real-world problems—like planning a field trip or designing a simulation—it's helpful to represent your thinking in different ways. Mathematicians and computer scientists use tools like **drawings**, **tables**, **graphs**, **equations**, and even **manipulatives** to better understand and communicate their ideas.

In our class activity, you may have calculated the total cost of a trip with an equation, but you could also represent that same information using a **table** to compare destinations, a **graph** to show cost vs. number of students, or a **flowchart** to visualize the logic of your decisions. Each method gives you a new perspective and helps you catch errors or make better choices.

By trying multiple representations, you build deeper understanding—and you get to choose the one that makes the most sense for the situation. As problems become more complex, switching between diagrams, models, and math helps you move from concrete ideas to abstract thinking like a true mathematician or programmer.

Extension Options

- Add a **weather simulation** decision (e.g., "Is it raining?" If yes, don't go to zoo).
- Try adjusting constraints (e.g., \$300 budget or 40 students) to see how the program handles changes.
- Create a **paper or digital version** of your final flowchart for display.

Questions (5)

1. What is a flowchart used for?

MULTIPLE CHOICE

Choose the correct answer:

- A. To draw pictures for a story
- B. To plan out the steps in a program or process
- C. To play a board game
- D. To count how many steps you walk

2. Which of the following is an example of applying math to a real-world problem?**Choose the correct answer:**

- A. Memorizing times tables
- B. Drawing a picture of a triangle
- C. Calculating how many chairs are needed for a school event
- D. Naming shapes

3. Why do scientists use models to study natural phenomena?**Choose the correct answer:**

- A. Because models are more fun than real things
- B. Because it's impossible to study nature in school
- C. Because models are safer, cheaper, or easier to test
- D. Because they are only required for homework

4. Which of these is a limitation of using a model?**Choose the correct answer:**

- A. It can help you make predictions
- B. It may not include every detail
- C. It shows things more clearly
- D. It helps reduce cost

5. What does it mean to act out a program?**Choose the correct answer:**

- A. Pretending to be a character in a game
- B. Using a computer to follow directions
- C. Performing the steps of an algorithm without a computer
- D. Copying code from a book

Answer Keys & Solutions

Questions

1. What is a flowchart used for?

MULTIPLE CHOICE

Correct Answer:

- A. To draw pictures for a story ✗ Incorrect
- B. To plan out the steps in a program or process ✓ Correct
- C. To play a board game ✗ Incorrect
- D. To count how many steps you walk ✗ Incorrect

2. Which of the following is an example of applying math to a real-world problem?

MULTIPLE CHOICE

Correct Answer:

- A. Memorizing times tables ✗ Incorrect
- B. Drawing a picture of a triangle ✗ Incorrect
- C. Calculating how many chairs are needed for a school event ✓ Correct
- D. Naming shapes ✗ Incorrect

3. Why do scientists use models to study natural phenomena?

MULTIPLE CHOICE

Correct Answer:

- A. Because models are more fun than real things ✗ Incorrect
- B. Because it's impossible to study nature in school ✗ Incorrect
- C. Because models are safer, cheaper, or easier to test ✓ Correct
- D. Because they are only required for homework ✗ Incorrect

4. Which of these is a limitation of using a model?

Correct Answer:

- A. It can help you make predictions ✗ Incorrect
- B. It may not include every detail ✓ Correct
- C. It shows things more clearly ✗ Incorrect
- D. It helps reduce cost ✗ Incorrect

5. What does it mean to act out a program?

Correct Answer:

- A. Pretending to be a character in a game ✗ Incorrect
- B. Using a computer to follow directions ✗ Incorrect
- C. Performing the steps of an algorithm without a computer ✗ Incorrect
- D. Copying code from a book ✗ Incorrect