TATA CONSULTANCY SERVICES | Discovery EDUCATION

IGNITE MY FUTURE

THINK SOLVE CREATE CONNECT

LESSON TITLE

Trouble in the Lab

Guiding Question: How does perspective change our understanding?

SUBJECTS

Science
English/Language Arts

COMPUTATIONAL THINKING PRACTICE

Recognizing and Defining Computational Problems

COMPUTATIONAL THINKING STRATEGIES

Find Patterns
Develop Algorithms

MATERIALS

Types of Biases student handout

Biases in Practice student handout

Controlling for Bias student handout

Computers with access to the Internet (optional)

Ignite Curiosity

- Can acai berries cure diabetes and heart disease?
- Can green coffee beans cure obesity?
- How much of our common knowledge is actually true?

In this lesson, students will use the computational thinking strategy of developing algorithms to control for qualitative and quantitative bias in a laboratory setting. In **THINK**, students act as board members of a group of scientific laboratories that want to control the quality of their company's work by learning about types of scientific bias. In **SOLVE** students review datasets from real-life biased experiments in order to identify types of bias in practice and determine patterns of cause and effect. In **CREATE** students use their observations about how qualitative and quantitative bias occurs to create two separate algorithms to prevent bias in their company's laboratories. In **CONNECT**, students identify how controlling for bias connects to careers and to problems of tomorrow.

Students will be able to:

- **Analyze** the characteristics of different types of scientific bias,
- **Evaluate** the effects of their controls on experiments and research projects, and
- **Create** a set of controls against scientific bias.

Students act as board members of a group of laboratories that want to make sure their labs are producing high-quality research.

1 **Read** the following scenario to students:

Imagine that you are the board of directors of a group of scientific laboratories. In the past year, scientists in your labs have conducted research that later studies have shown was flawed and biased. Now, you need to make sure the quality of your company's work stays high by learning about types of bias and protecting your labs against them. Your reputation for performing important research depends on this. Let's see how well you do!

2 **Instruct** students to read the following abstract from "Dietary supplements for improving body composition and reducing body weight: where is the evidence?" published in the *International Journal of Sports Nutrition and Exercise Metabolism:*

There is no strong research evidence indicating that a specific supplement will produce significant weight loss (>2 kg), especially in the long term. Some foods or supplements such as green tea, fiber, and calcium supplements or dairy products may complement a healthy lifestyle to produce small weight losses or prevent weight gain over time. Weight-loss supplements containing metabolic stimulants (e.g., caffeine, ephedra, synephrine) are most likely to produce adverse side effects and should be avoided.

Ask students to think about how diet pills and weight-loss remedies are marketed. Do they include the information listed above? Why or why not? Ask students why they think the information might be different when marketed on a product than when it's presented in a medical journal.

3 **Distribute** the Types of Biases student handout. Review the biases with the students. Elicit possible scenarios that could arise from each type of bias in a scientific environment.

4 **Lead students to consider** the importance of accurate scientific studies using the following guiding questions:

- What could happen if you claim a product is more effective than it actually is?
- What might happen if you ask survey participants a question when they are under time pressure?
- How would someone respond if you ask a question about something personal and show through your words or body language that you will judge them if they give a certain response?
- What could happen if you test a drug on only women or only men?

5 **Explain** that in this lesson, you will explore how to prevent bias in scientific studies using algorithms. If necessary, review the definition of algorithm with students (a process or set of rules to be followed when calculating or problem solving).

Ask students the following questions:

- What would the benefits be of using algorithms in laboratory settings?
- How does breaking a process down into steps that we use every time we encounter a problem help us solve that problem?
- How can using algorithms help us avoid bias?

Students will read a dataset describing various biased experiments. They will then identify the type of bias (or biases) present in each experiment, determining the causes and effects of the biases on the experiments' findings.

1. **Distribute** the Biases in Practice student handout.

2. **Have students consider** how bias can arise in scientific studies. Read the first biased experiment aloud, stopping after each sentence or at appropriate points.

   Ask students the following questions:
   - When should researchers have been aware that there was a potential issue with this drug?
   - How could we use that information as we write algorithms?

3. **Working individually**, students should use their Biases in Practice student handout in conjunction with their Types of Bias student handout to identify the bias or biases present in each scenario. Have students share their thoughts about the biases with a partner and identify the extent to which bias affected the outcome of the experiment. Regroup as a larger class to share answers.

4. **Check for understanding** by asking students the following questions:
   - Were the causes of the bias in these experiments preventable?
   - What steps would you take to reduce the elements of bias in these experiments?

Students use their observations to write two algorithms: one that serves as a control for quantitative experiments and one that serves as a control for qualitative experiments. They will then apply their algorithms to two experiments they have read about, determining the effects that these algorithms would have had on the original experiments.

1. **Divide** students into small groups of three to five. Explain that now that they understand the causes and effects of scientific bias, they will construct algorithms to prevent bias in their own labs.

2. **Students should discuss** the patterns of bias they read about and create two multi-step algorithms. If students struggle to identify steps for their algorithms, direct them back to the steps of the scientific method (make an observation, form a question, form a hypothesis, conduct an experiment, analyze the data, and draw a conclusion) and have them evaluate each experiment in terms of where bias appeared in terms of the scientific method.

3. **Distribute** the Controlling for Bias student handout. Individually, students should select two experiments from the dataset and describe how their group's algorithms would have changed the outcome of these experiments.

4. **Regroup and elicit algorithms** from several members of different groups. Discuss the similarities and differences among groups' algorithms.

5. **Summarize** by inviting students to share out how identifying patterns and writing algorithms to control for scientific bias can help our understanding of the world around us.
   - How did you solve this problem without using a computer?
   - How could a computer help you with next steps?
   - How did identifying and recognizing patterns help you think like a computer?

Select one of the strategies listed below to help students answer these questions:

- **How do this problem and solution connect to me?**
- **How do this problem and solution connect to real-world careers?**
- **How do this problem and solution connect to our world?**

1. **Write** the three questions on PPT or flip chart slides and invite students to share out responses. Display chart paper around the room, each with one question written on it. Ask students to write down their ideas on each sheet.
2. **Assign** one of the questions to three different student groups to brainstorm or research, and then share out responses.
3. **Direct** students to write down responses to each question on a sticky note, and collect them to create an affinity diagram of ideas.

How does this connect to students?

It is quite common to see pseudoscience in advertisements, both on television and on the Internet. By understanding scientific biases of all kinds, particularly reporting bias, students will be less likely to buy into bogus claims without first researching more on their own. This could help students save money—and even their own health—in the future as they learn to evaluate scientific claims.

How does this connect to careers?

Scientists need a clear understanding of types of bias to avoid it in experiment design and implementation, as well as in the review and recreation of colleagues' work.

Engineers creating new technologies need an accurate understanding of how materials will or will not function, and thus need to be able to identify accurate and biased studies.

Researchers of all kinds need to avoid bias and understand it when they encounter it in their sources.

How does this connect to our world?

Particularly when it comes to sensitive issues such as weight loss, new "miracle cures" and "superfoods" appear in headlines in various types of media almost daily. Learning how to evaluate scientific claims, identify scientific bias, and avoid buying into such claims is important to avoid wasting money and endangering one's health. Pop-science is increasingly prevalent in various forms and is rarely subject to the kind of stringent evaluations that legitimate, unbiased scientific studies undergo.

National Standards

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)	**ETS1.A: 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. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** ▪ 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) ▪ Models of all kinds are important for testing solutions. (MS-ETS1-4)	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

National Standards

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.RI.6.4
Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.

CCSS.ELA-LITERACY.RI.6.6
Determine an author's point of view or purpose in a text and explain how it is conveyed in the text.

CCSS.ELA-LITERACY.RI.7.4
Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of a specific word choice on meaning and tone.

CCSS.ELA-LITERACY.RI.7.5
Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to the development of the ideas.

CCSS.ELA-LITERACY.RI.7.6
Determine an author's point of view or purpose in a text and analyze how the author distinguishes his or her position from that of others.

CCSS.ELA-LITERACY.RI.8.4
Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.

CCSS.ELA-LITERACY.RI.8.6
Determine an author's point of view or purpose in a text and analyze how the author acknowledges and responds to conflicting evidence or viewpoints.

K-12 COMPUTER SCIENCE FRAMEWORK

Practice 3. Recognizing and Defining Computational Problems
The ability to recognize appropriate and worthwhile opportunities to apply computation is a skill that develops over time and is central to computing. Solving a problem with a computational approach requires defining the problem, breaking it down into parts, and evaluating each part to determine whether a computational solution is appropriate.

Types of Bias

Selection Bias happens when researchers either leave groups of people out of a study or only test certain groups of people. A study testing the effects of one drug on a particular age group, for example, should not be used to predict the effects of that drug on other age groups.

Procedural Bias occurs when research subjects encounter pressure. Notably, this can happen when researchers rush subjects or encourage them to be faster.

Measurement Bias happens when researchers make errors as they collect data. Measurement bias can occur as a result of Instrument Bias, in which instruments used to measure results are not functioning properly.

In **Interviewer Bias**, test subjects pick up on the researcher's body language, which influences their answers.

Similarly, **Acquiescence Bias**, also known as Response Bias, happens because test subjects are likely to agree with positive statements a researcher makes.

Reporting Bias occurs when results are reported in a way that shifts the focus from the primary findings, even going so far as to blow statistically insignificant or otherwise faulty data out of proportion into blanket statements (such as "X Cures Cancer!")

Design Bias is bias about biases. In short, design bias occurs when researchers designing an experiment ignore possible biases that could occur as they conduct research. For example, a researcher might know that she is not testing any subjects over the age of 50 and yet fail to account for this in her experiment design or reporting.

Bias in Practice

Sleepy Women

Scientists tested a particular drug for morning sickness, the nausea many women experience when they are pregnant, in the 1950s and 1960s. However, they found out too late that the drug caused serious harm to these women's babies before they were born. This tragic study led to the exclusion of women of childbearing age from many future drug trials.

Therefore, when testing a sleeping pill, scientists only studied how it worked on men, particularly in terms of how long it took for the drug to leave the body. This proved problematic, though, because males and females react to drugs differently. When the drug was marketed to the public, some women taking it ended up walking or even driving in their sleep. Researchers later found that eight hours after taking the pill, 3 percent of men still had enough of it in their system to harm their daily functioning, while 10 to 15 percent of women did.

What kind of bias(es) does this experiment illustrate?

What caused the bias(es)?

How much did the bias(es) affect the experiment's findings?

What can we infer about the causes and effects of this type of bias?

Bias in Practice

The Mysterious Ray

After many breakthroughs in physics in the late 1800s that included the discovery of X-rays, radioactivity, and electrons, scientists believed that other types of radiation were present that had not been discovered yet. A French researcher witnessed what he thought was a new type of radiation, which he called N-rays. More than 100 scientists claimed to be able to detect N-rays in over 300 objects. However, British researchers were unable to duplicate the experiment. It was later suspected that the French researcher's assistant had misled his boss by claiming to observe the same reactions that his boss saw, while probably not seeing them.

What kind of bias(es) does this experiment illustrate?

What caused the bias(es)?

How much did the bias(es) affect the experiment's findings?

What can we infer about the causes and effects of this type of bias?

Bias in Practice

The Marriage Panic

In the mid-1980s, a popular magazine published the claim that women over 40 had a greater chance of being killed by a terrorist than of getting married. However, the researchers had based that claim off a model that was meant to compute past, not future actions. Furthermore, the only group that the researchers studied was women with college degrees, leading to a sample size of only 1,500. A quick look at Census Bureau data showed that even then, the women's chance of getting married was much, much higher than predicted. Census Bureau information showed that a 40-year-old's chance of getting married was more than ten times what the study had predicted, not taking into account unmarried couples living together, a group which increased by 213% during the 1980s.

What kind of bias(es) does this experiment illustrate?

What caused the bias(es)?

How much did the bias(es) affect the experiment's findings?

What can we infer about the causes and effects of this type of bias?

Bias in Practice

"Me Too!"

Many studies, particularly regarding behavior, rely on surveys in which respondents are asked to what extent they agree with a particular statement. However, one researcher found that when given a survey, test subjects were more likely to agree with the statements provided. This was even true when they were given two tests, one with statements that were the opposite of the first. While we might expect subjects to respond negatively to the opposite statements, they still responded positively. This lends authority to the idea that subjects tend to agree with statements, particularly when they are unsure about their answers.

What kind of bias(es) does this experiment illustrate?

What caused the bias(es)?

How much did the bias(es) affect the experiment's findings?

What can we infer about the causes and effects of this type of bias?

Bias in Practice

Missing the Point

In the early 2000s, a major pharmaceutical company was marketing a new drug. However, there was one big problem: the drug did not help the problem it was supposed to. Instead, it helped a variety of other, smaller problems. When publicizing the drug, the company ignored the fact that the drug did not address the major problem, but instead focused on the more minor problems that the drug did address. Furthermore, the drug company encouraged researchers to publish information on groups of people that were too small to be statistically significant. Then, they cited this research as an example of the drug's benefits.

What kind of bias(es) does this experiment illustrate?

What caused the bias(es)?

How much did the bias(es) affect the experiment's findings?

What can we infer about the causes and effects of this type of bias?

Bias in Practice

Oops…

In the 1948 presidential election, the *Chicago Tribune* famously printed the headline "Dewey Defeats Truman"—a headline that turned out to be false. The newspaper had printed the headline before the final results of the election had come in. The reason the *Tribune* printed this headline was that the reporters had trusted the findings of a company that had conducted telephone surveys about which candidate people voted for. At that time, only wealthier people had telephones. The wealthy were more likely to vote for the Republican candidate (Dewey) than the Democratic incumbent, Truman.

What kind of bias(es) does this experiment illustrate?

What caused the bias(es)?

How much did the bias(es) affect the experiment's findings?

What can we infer about the causes and effects of this type of bias?

Controlling for Bias

Write the final steps of your algorithms in the space provided below.
Quantitative Algorithm:

Qualitative Algorithm:

Once you have written your algorithms, fill out the following graphic organizer to explain how and why these algorithms would have changed the outcomes of two of the experiments from your data set:

Experiment	How would your algorithm have changed the outcome?	Why would your algorithm have changed the outcome?
Experiment 1 Title:		
Experiment 2 Title:		