Hack the Solar System

Educator's Guide

What is computational thinking?
Computational thinking is a way of approaching problems and solutions within the context of computing. It is thinking like a computer scientist.

Why is computational thinking important to science learning?
Scientists rely on computing processes to create models and simulations, gather and analyze data, form the conclusions that they draw, and communicate their results to others.

Hack the Solar System

Planning:

Materials and supplies needed:

chromebooks/laptops, access to the internet
Basketball or Soccer ball and a ping pong ball or golf ball
Hack the Solar System Worksheet

Visit: www.hackthesolarsystem.org to test the simulation

Introduction/Opening Routine:

Learning Targets Addressed in Lesson:

Computational Thinking Concepts*
Logic: being able to explain why something is the way it is.
Algorithms: developing a step-by-step solution to the problem, or the rules to follow to solve the problem
Decomposition: breaking down a complex problem or system into smaller, more manageable parts
Abstraction: focusing on the important information only, ignoring irrelevant detail
Tinkering: trying out something new to discover what it does and how it works

As defined by Barefoot Computing & BBC Bitesize

Standards:

NGSS
HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [*Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.*]

CSTA

3A-DA-12: Create computational models that represent the relationships among different elements of data collected from a phenomenon or process. *Computational models make predictions about processes or phenomenon based on selected data and features. The amount, quality, and diversity of data and the features chosen can affect the quality of a model and ability to understand a system. Predictions or inferences are tested to validate models. Students should model phenomena as systems, with rules governing the interactions within the system. Students should analyze and evaluate these models against real-world observations.*

Possible misconceptions students will have (what students will find difficult):

- There is not a simple connection between the inputs and outputs. The simulation applies Newton's Law. It explains at a high level what the inputs and outputs represent, but students will not know exactly what is happening. They will know that the input and output is related, but not the exact mechanism of the relationship.
- The concepts of mass, force, velocity, acceleration in a prior lesson.
- Students will likely picture gravity as a force that pulls down, rather than a force that pulls two bodies towards each other.

Interest/Hook:

- How do we use models and simulations in science?
- Display the simulation:
  - What is included in the simulation? (planets, sun, asteroid belt)
  - What is not included or misrepresented? (sizes and distances are not proportional)

Learning Activities

Mini Lesson:

Steps:

- Display the Law of Universal Gravitation:

$$F = \frac{GM_1M_2}{d^2}$$

Where:

F = force due to gravity.
M_1 = mass of the first body
M_2 = mass of the second body
d = distance between their centers.
G = Gravitational Force Constant

- Explain in general terms how the law works:

"For any two objects in the universe, the gravity between these two objects depends only on their mass and distance."

- Student simulation:
    - Ask for two student volunteers
    - Give one a soccer or basketball and the other a ping pong ball
    - Have the students identify where the center of mass might be (It should be slightly off center of the basketball.)
    - Both students should rotate around the center of mass (The student with the basketball will just rotate around in place. The student with the tennis ball will walk around as if in orbit.)
- Group discussion:
    - Is gravity a force that pulls straight down? Or a force that pulls two bodies towards a center of mass?
    - How can computing help us?
        - "We can explore the Law of Universal Gravitation by having a computer do the math for us."
        - "This simulation focuses in on what is most important to the Law of Universal Gravitation."

Learning Activity:

Steps:

- Have students go to the simulation web page
- Distribute the Hack the Solar System worksheet
- Ask students to work in pairs to
    - Make a prediction
    - Run the simulation according to the instructions and record the results
    - Analyze the results and formulate a hypothesis

Debrief/Reflection Activity:

Steps:
Group discussion:

- Ask groups to share out their analysis and hypothesis
- Explain any misconceptions
- Ask students to come up and demonstrate with the sports balls if necessary

Exit Ticket:

- In their science notebooks. Students should explain the Universal Law of Gravity in their own words/drawings.

Method of Assessment:

- Hack the Solar System worksheet
- Exit ticket in science notebook

Universal Design & Differentiation:

- Given time, the simulation would have multiple input options: a slider, block code, and a text editor. Students can self-select their input method
- Teacher can model the example provided in the worksheet.
- Students can use writing and drawing to communicate meaning.
- Given time, the simulation would be compatible with accessibility tools such as text readers.