Unplugged Algorithm Activity #1: Ping-Pong Rescue

The ability to sequence instructions into simple algorithms is fundamental to computational thinking. In this activity, students work in teams of 2 to 4 to create a simple algorithm that guides one of their team members, who is blindfolded, to rescue a ping-pong ball. At the same time, **students develop their core competencies in communication and critical thinking, as well as their curricular competency in ideating,** which involves generating potential ideas or adding to others' ideas, screening ideas against criteria or constraints, and choosing an idea to pursue.

Activity Overview

Estimated Time: 1h

Materials for each group of 2 to 4 students:	Preparation:
• Ping-Pong Ball • Blindfold • Paper and Pencil • Cup (Optional) • Printed Analog Clock Face (Optional) **Materials for each student:** • Self-Assessment Student Sheet (Optional) • Pencil (Optional)	• Arrange the classroom such that students can move freely. Create "obstacles" using desks or chairs to represent areas that students cannot enter. • Optionally, arrange for the activity to be completed in the gym or outdoors using cones, jump ropes, or hoops as obstacles. • Print out 1 Printed Analog Clock Face per group. (Optional) • Print out 1 Self-Assessment Student Sheet per student. (Optional)

Note to the teacher: A printable analog clock face can be found from the following website: http://www.sawyoo.com/postpic/2010/11/blank-clock-face_105120.jpg.

Warm-up: Estimating Algorithmic Complexity (10 minutes)

Ask students to think about an everyday task, such as making a peanut butter and jelly sandwich, or tying their shoes. Facilitate a class discussion or ask students to discuss in small groups using the following prompts:

- How many steps do you think it will take to accomplish the task?
- What are the steps to complete the task?
- What obstacles might you encounter during the task?

Activity: Algorithmic Construction (30 minutes)

Arrange students into groups of 2 to 4. Ask each group to determine the role(s) for each person:

The **Robot** is blindfolded and follows the instructions given by the Walker and Turner.
The **Walker** calls out how many steps and the size of the steps the Robot should take.
The **Turner** calls out which direction and how far the Robot should turn.
The **Recorder** writes down each instruction given to the Robot.

In a group of 4, each person has one role. In a group of 3, one person can be the Turner and the Recorder. In a group of 2, one person is the Robot, while the other person is the Walker, the Turner, and the Recorder.

Getting Started:

1. Have each group decide on a start and end position. The positions may be close together or far apart. Groups may add obstacles, but safety should be first concern.
2. Ask each group to place the ping-pong ball between the start and end positions.
3. Give each group a minute to write down their estimate for how many instructions the Robot will need to retrieve the ping-pong ball and bring it to the end position.
4. Have the Robot stand at the start position and apply the blindfold.
5. Have the Walker and Turner stand at the end position.

General Rules:

- The Walker and Turner take turns giving instructions to the Robot to retrieve and deliver the ping-pong ball to the end position.
- The Robot must respond to each instruction with “OK” if the instruction is valid, or “No” if the instruction is invalid. A list of valid instructions is provided below.
- The Recorder must write down each instruction only after the Robot says “OK”.
- Once the Robot successfully brings the ping-pong ball to the end position, the Recorder must write down the total number of instructions.

Instructions:

Instruction	Who can give the instruction	How to record the instruction
Number of steps in whole numbers and size of the steps, large or small. Examples: • “3 large steps” • “2 small steps”	Walker	<#><SIZE> Examples: • 3L (3 large steps) • 2S (2 small steps)
Direction to turn, left or right, and size of turn, large or small. Examples: • “left large turn” • “right small turn”	Turner	<DIRECTION><SIZE> Examples: • LL (left large turn) • RS (right small turn)
Undo To reverse the last instruction,	Walker or Turner	UNDO
Pick up To pick up the ball.	Walker	PICK UP

Reflections: Refactoring Algorithms (20 minutes)

Identify the series of instructions that each group recorded as an **algorithm.** Explain that an algorithm is a solution to a problem. It is broken down into individual steps and can be repeated.

Ask each group to analyze their algorithm and to look for sequences of instructions that can be combined. For example, 2L followed by 1L can be combined into 3L. The goal is to have the least number of instructions but still produce the same result. This is called **refactoring.**

Facilitate a class discussion, or alternatively, ask students to reflect individually or in small groups using the following prompts:

- How did your estimate compare to the actual number of instructions in your algorithm?

- Did refactoring your algorithm help reduce the number of instructions? Why or why not?
- What was easy or difficult about making the initial estimate?
- What was easy or difficult about being the Walker or the Turner?
- What was easy or difficult about being the Robot?
- What was easy or difficult about being the Recorder?
- How would you combine existing instructions to make new instructions? Examples:
    - A "knight" move in chess would be 2L + RL + 1L
    - "Turn around" would be LL + LL

Assessment

Criteria	Approaching	Meeting	Exceeding
Student shared ideas during the warm-up.			
Student worked together with his or her team to generate their algorithm.			
Student contributed to the refactoring process either by coming up with ideas, building on others' ideas, or giving constructive feedback.			
Student shared his or her reflections either individually or in a group discussion.			

Extensions

Allow the word "double" to be used as a modifier

For example, 5DL would mean 5 double large steps where each step is twice the size of a regular large step, or LDS would mean a double small left turn, which would be half the size of a regular small left turn. This is analogous to clothing sizes, in which XXL is bigger than XL, but XXS is smaller than XS.

Include a cup at the end position

The Walker or Turner now need to tell the Robot to "put down" in order to place the ping-pong ball in the cup.

Include a printed analog clock face

Instead of using the instructions RS and LL, the Turner uses the clock face to direct the turns using instructions such as 11 o'clock or 4 o'clock, which would cause the Robot to turn left or right by the indicated increment and be recorded as 11:00 or 4:00, respectively.

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Include the "If-Then" instruction

The If-Then instruction must be agreed upon before the Robot begins. An example would be, "If you reach an obstacle, then LL and 1L."

Self-Assessment Student Sheet

Give an example or provide evidence of how you demonstrated or accomplished each of the following statements during this activity. Examples and evidence can include sketches, written descriptions, and references to photos or videos.

Statement	Example or Evidence
When thinking about an everyday task, I expressed my ideas and/or supported other students by actively listening to their ideas.	
During the activity, I took on an active role in my group and helped my group build our algorithm to retrieve the ping-pong ball.	
At the end of the activity, I thought about what was easy or challenging about my role and the roles of other members in my group.	
During the refactoring process, I helped my group by analyzing our algorithm and looking for sequences of instructions that could be combined.	